TomTec-Arena™ 1.1

Operating Manual

CE 0123

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0 Table of Contents

1 Introduction

In the following text TomTec Imaging Systems GmbH will be called TomTec.

1.1 About this Manual

Page and chapter numbers are displayed at the bottom of each page. The chapter number is displayed first, followed by a dash, then the page number.

Examples, suggestions and warnings are included to help you to get started and to give you advice on important setups and results. This information is indicated via symbols. The explanations for those symbols are:


The caution symbol indicates the most important information, or warnings.

The stop symbol highlights important information. You should stop and read before continuing.


The bulb symbol indicates a suggestion or an idea that simplifies using the software. It can also refer to information available in other chapters.

1.2 Interpreting Symbols on the Product

Symbol	Location	Description
	Software CD, Packaging	Read operating manual prior to use.
	Software CD	Production Year and month
	Software CD, Packaging	Conformity assessment procedure according to directive 93/42/EEC Annex II.3
	Software CD	Lot-Number of Software: Indicates the lot code and revision level of the software.
	Software CD	Reference Number and Order Code of the product
Reg. No.	Software CD	TomTec Registration number

1.3 Product Description

TomTec-Arena is a clinical software package for reviewing, quantifying and reporting digital medical data. TomTec-Arena runs on high performance PC platforms based on Microsoft Windows operating system standards. The software is compatible with different TomTec Image-Arena™ platforms, their derivatives or third party platforms.

Platforms enhance the workflow by providing the database, import, export and other services. All analyzed data and images will be transferred to the platform for archiving, reporting, and statistical quantification purposes.

TomTec-Arena consists of the following optional clinical application packages:

- Image-Com©
- 4D LV-Analysis© and 4D LV-Function™
- 4D RV-Function©
- 4D Cardio-View™
- 4D MV-Assessment©
- Echo-Com©
- 2D Cardiac Performance Analysis©
- 2D Cardiac Performance Analysis MR©
- 4D Sono-Scan™

1.4 Intended Use

TomTec-Arena software is a clinical software package designed for review, quantification and reporting of structures and function based on multi-dimensional digital medical data acquired with different modalities.

TomTec-Arena is not intended to be used for reading of mammography images.

1.5 Indication for Use

Indications for use of TomTec-Arena software are diagnostic review, quantification and reporting of cardiovascular, fetal and abdominal structures and function of patients with suspected disease.

1.6 Intended User Group

Intended user groups are trained and licensed medical practitioners or assistant medical technicians.

1.7 System Hardware Components

For hardware details please refer to the Technical Specification of this TomTec software.

1.8 Safety Precautions

1 Please carefully read the information of this section before using the product. This section contains important information on operating safety and handling of the product as well as information on service and support.

3 

Only trained and licensed physicians and clinical staff who is instructed by trained and licensed physicians or assistant medical technicians are authorized to use the product.

4 

(According to common medical sense and the principles of differential diagnosis,) any diagnostic finding derived from usage of this product must be confirmed by additional diagnostic investigations prior diagnosis performed by a physician.

5 
U.S. Federal law restricts this product to sale by or on the order of a physician.

6 

That product is not intended to be used for emergency diagnosis.

1.8.1 Data Handling

7 
Due to our continuous development of leading-edge research products problems with your archive of research data may occur, in case:

- Subsequent software versions or third party software use different data formats. (Relief: Store data on a separate hard drive.)
- Special measurement and archived views provided by one product version cannot be restored with future versions.

8  Before saving, editing, or reviewing the data of a patient, ensure that its contents correspond to the patient name. This provides additional assurance that the stored data correspond to the correct patient.

10  The quality of any exported object highly depends on the settings performed to the exporting file formats (e.g. compression of images). Keep this fact in mind that information can be lost that way. The physician has to decide whether the information contained in an exported object can be used for making diagnostic decisions.

13  The user is responsible for the content of reports, findings records and other patient information.

19  Saved analyses are not automatically backed up nor backed up with the host platform data. Please contact your service representative for backup.

1.8.2 Installation and Maintenance

21 

Only TomTec trained and authorized personnel may perform installation, setup, upgrade, maintenance, service and any modification of this product; otherwise, warranty may be void.

Technical documentation is only available together with an adequate training. Please contact TomTec for further information.

22  TomTec Imaging Systems GmbH assumes no liability for problems attributable to unauthorized modifications, additions, or deletions to this product, or unauthorized installation of third party software.

As manufacturer and distributor of this product, TomTec is not responsible for safety, reliability and performance of a system, if:

23

- installation, configuration or modifications are performed by persons, who are not authorized by TomTec.
- the product is not operated in accordance with the operating manual.
- the product is operated outside of its operating conditions.
- the product is operated outside of the specified operating environment.

24 The user is responsible for keeping up to date the software versions of:

- the operating system (e.g. Service Packs)
- this product used in combination with the operating system.

25 The hardware this product is running on has regularly to be maintained.

26 The user is responsible for all changes to the system settings. This can lead to system damage and warranty void.

31 The user is responsible for the installation of any third party software. This software may be incompatible to TomTec products. Contact your local TomTec representative for further information on installing third party software.

Log on as "Administrator" before licensing this product or module. The operation of some TomTec products depends on superior licenses.

32

1.8.3 Patient / User Safety

35 The user must be satisfied with the suitability and completeness of a study for an analysis with this product. If not, the acquisition has to be repeated. For information about performing an acquisition, which is suitable for an analysis with this product, please refer to the operating instructions provided by the manufacturer of your ultrasound equipment.

36 The user must be satisfied with the suitability and completeness of a Data Package for an analysis with this product. If not, the composition of the Data Package has to be checked upon its usability with this product. For information about composing a Data Package, which is suitable for an analysis with this product, please refer to the operating instructions of the data management platform on which this product is installed to.

37 The information contained in this manual is intended only for the operation of this product. It does not include information on images derived from imaging modalities like US, XA, NM or MR and how to acquire them. Please refer to the operating instructions of your imaging equipment for further information.

1.8.4 Measurements

38 The complete anatomy of the left ventricle has to be acquired and has to be visible in the datasets.

39 The user is required to determine whether the labeling of an image is correct. Double-check the stage, view and acquisition method of each image. TomTec Imaging Systems GmbH is not responsible for the correctness of image labeling.

The user is responsible for determining if artifactual characteristics exist. Artifacts can severely affect the image quality and require a reacquisition. Examples of artifacts are:

40

- Obvious discontinuity due to a jerky motion during acquisition or because the acquisition range was left
- Excess shadowing of images
- Poorly defined anatomy or evidence of distorted anatomical representation.

In the case of a poorly reconstructed image, as determined by the above criteria or by the user's clinical experience and training, dimensional measurements should not be made. If for any reason measurements are made using a poorly reconstructed image, these measurements should not be used for making diagnostic decisions.

41

The user must be committed to the accuracy of the existing images and measurement results. Image scans should be repeated if there is the slightest doubt as to the accuracy of images and measurements.

42

Some patient data contain ECG data. ECG data is intended only for basic rhythm identification, and not for diagnostic purposes.

43

The user is responsible for determining if the selected kind of Manual calibration is suitable for the corresponding dataset. In case of incorrect usage incorrect measurement results may occur.

The user is responsible on its own for his determination of on-screen graphic symbols superimposed over an image (cut planes, measurements, landmarks, contour tracing and editing of the listed afore). The determination belongs to dedicated placement, use of dedicated contents of images and use of dedicated calibrated images.

44

45 The user is responsible for determining if the desired measurement is suitable for the corresponding dataset and for determining if the measurement results are applicable for diagnostic decisions. In case of M Mode, Doppler and 2D Images measurements only the desired and reasonable measurement packages should be used for the according images. In case of incorrect usage incorrect results may occur.

46 The automatic recognition of the end-systolic and end-diastolic frame could be incorrect in some datasets. In case of an incorrect end-diastolic or end-systolic frame the user must manually set the correct frame.

47 The user has to check ES and ED markers and correct their position if necessary.

48 The user has to check views and manually adjust the views if necessary.

49 The user has to check initial Beutel™ and manually adjust the Beutel if necessary.

50 The user has to manually adjust the dynamic Beutel and/or set a new starting point if necessary.

Measurement Accuracy

The measurement accuracy of any measurement function is only as precise as the maximum acquired resolution in the screen projection of an image. The accuracy depends mainly on the acquisition method and the user skills. For detailed information about acquisition methods and accuracies refer to the manual of the acquiring device.

51 All measurements are calculated from the relative positions of on-screen graphic symbols superimposed over an image. Therefore, the validity of the measurements with respect to the image depends directly on the user skills in positioning the graphic symbols over features of interest in the image. When performing measurements, always be aware of this source of human error.

Mandatory requirements for each measurement are the correct reproduction of the acquired anatomy and the performing of measurements according to the 'lege artis' standard.

The accuracy of the Measurement Tools was verified on a representative test-phantom. For information about measurement functions and their corresponding accuracy please refer to the measurements chapter of the particular product.

52 The system is not developed to have an automatic diagnostic tool. This product provides suggestions for the contour finding. Starting with these suggestions the user has to adjust the settings for a contour and has to accept the calculated contour suggestion.

The contour finding and the calculation of a volume should be repeated if there is the slightest doubt as to the accuracy of the contour suggestions or of the volume.

53  The user is responsible for the definition of cardiac contours in acquired views.

54  The user is responsible on its own for all diagnoses and medical treatments, which he infers from a dataset he analyzed with this product.

55  Datasets containing multiple heart cycle data will automatically be cropped to one heart cycle. Only the last heart cycle of a multiple heart cycle dataset will be used for analysis of Toshiba Artida datasets. For all other datasets, the first heart cycle will be used.

56  Datasets have to be acquired with a minimum frame rate of 10 frames/heart cycle.

1.9 Licensing

TomTec software products are password protected in order to avoid unauthorized use. For information about the licensing process, please refer to the Data Management Platform (e.g. Image-Arena™) Manual.

1.10 Data Formats

For information about data formats which can be read by this TomTec software, please refer to its Technical Specification.

1.11 Data Compression

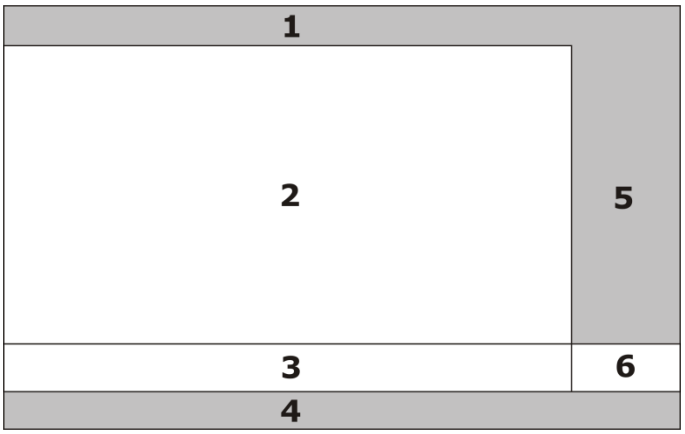
For information about data compression used for storing images from this TomTec software please refer to its Technical Specification.

2 Image-Com© 5.2

This chapter introduces to the functionalities of this TomTec software and describes main interface elements of it.

2.1 Main interface elements

Image-Com is started from a Data Management Platform.



Interface elements of Image-Com

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Preview window**	displays all image items related to the study shown at (6).
4	**Patient information**	displays the most important Patient information and the name of the current user.
5	**Toolspace**	offers special functions for analysis handling and for performing analyses and measurements.
6	**Study window**	displays all studies related to the patient.

The Image-Com Review Display (Multi Tiling mode) consists of 1 up to 12 tiles. Each of these tiles can display 2D or 3D datasets. 3D datasets are marked with a special overlay in the Study content preview.


Review of 3D datasets is licensed separately. Review of 3D data is only available, if the required module for displaying it is installed and the associated license is available.

XA specific overlays

XA images contain 2 projections with associated angles. This information (e.g. RAO 30° CAUD 0°) is displayed in the upper left hand of each tile containing a XA clip and in the preview icon of the clip.

View direction during the XA acquisition

Primary Angle		**Secondary Angle**	
Abbreviation	Description	Abbreviation	Description
RAO	right anterior-oblique	CAUD	caudal
LAO	left anterior-oblique	CRAN	cranial

Toolbar

Button, Combo box	Name	Function
	**Reset**	displays the dataset as originally displayed after it was just opened.
	**Save AVI or BMP**	opens the Export dialog to store the actual screen content as BMP or AVI. Type in a file name, select the destination of your export and click on the Save button. The AVI recording starts automatically and stops automatically after a preset time span.
	**Save Secondary Capture**	creates and stores a Secondary Capture of the Workspace content (still image or video). It will be displayed as a thumbnail within the Preview Window.
	**PDF Quick Print**	opens the Export dialog to store the actual screen content as PDF. Type in a file name, select the destination of your export and click on the Save button. If manual selection is disabled the PDF will be stored to a default directory.
Navigation Tools Keyboard shortcuts can alternatively be used for the navigation within tiles. Please refer to the chapter 12 Table of Keyboard Shortcuts.		
 e.g.	**Layout**	displays a list with available Screen tilings. Select one to display items of the active study in the selected Screen tiling. This button always displays the currently selected Screen tiling. A tiling **XxY** displays the tile(s) in **X** column(s) and **Y** row(s). At each study opening a modality specific Screen Tiling is set by default. The default Tiling can be configured in the configuration dialog.

	**Previous Page**	Pages to the previous set of images from the study in steps according to the current tiling mode. The Play functionality is activated with every paging operation. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Next Page**	pages to the next set of images from the study in steps according to the current tiling mode. The Play functionality is activated with every paging operation. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.

Playbar Tools at the Toolbar / Toolspace

The stepping through a sequence is construed as a closed loop. E.g. when reaching a limit on one side, the loop is closed by proceeding from the respective other sequence limit.

A keyboard shortcut can alternatively be used for stepping through a sequence. Please refer to the chapter 12 Table of Keyboard Shortcuts.

	**First Frame**	shows the frame within its sequence whose position is defined by the lower left limiter of the Frame slider. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Previous Frame**	decrements the actual frame. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Play/ Pause**	stops the sequence(s). A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Play/ Pause**	starts playing the sequence(s) forwards. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts. Play Forward is the default setting at opening a study.
	**Next Frame**	increments the actual frame. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Last Frame**	shows the frame within its sequence whose position is defined by the lower right limiter of the Frame slider. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
 **Free**  **Start**	**Synchronization**	offers three kinds of synchronization: Free – Each sequence is displayed with its speed at its acquisition. Start – All sequences are synchronically started and displayed with their speed at their acquisition. Sequences with higher heart rates will stop earlier than slower ones. The next run will be started after the end of the slowest sequence.

 **Align**		Align – All sequences are synchronically started and displayed with a common speed. The default synchronization is No Sync.
	**Speed**	sets the replay speed for the sequence(s) at the Workspace. It can be selected by clicking this button in 10% steps. The default Replay Speed is 100%.
	**Display Pixels 1:1**	toggles the size of the displayed datasets between showing them in original pixel size or showing them in maximal size within the particular Tiling mode.
	**Export measure-ments**	exports a DICOM SR or XML file containing measurements to AE-title or path defined by the administrator. If enabled by the ad-ministrator.
	**Settings**	General settings for initial layout, hot regions, animations and quality of video export can be defined within this dialog.
	**About Box**	opens a box with information about the product for mainte-nance.
	**Launch Echo-Com**	launches a CAP for reviewing stress echo studies and performing Wall Motion Assessments. For more information about this CAP, its contents and its functionalities please refer to the Echo-Com manual.
	**Exit**	closes the application.
	Return/ Enter key	toggles the display of the active tile between showing it in max-imum size at the Single Screen or showing it within the selected Tiling mode. Alternatively: Use double clicks in series to perform the same display toggling.  Zoomed datasets and Frame slider settings are kept, when using the display toggling.

2.2 Workspace

The filling of the particular tiles within the Workspace takes place in a left to right and top to bottom order. Click inside a tile to tag it as your active dataset. Four colored corners indi-cate the tile as the active one.

Only for displaying Volume datasets within one tile:

Each MPR displayed within a sub tile represents a visible cut plane of a volume dataset. The position of a cut plane is indicated by a dashed line shown within other MPRs and drawn in as a plane within the spatial arrangement of MPRs. These lines are called LOIs (LOI - Line

Of Intersection). The Spatial arrangement of MPRs is a 3 dimensional arrangement of particular MPRs representing a Volume dataset, which can be animated.

Each sub tile has four colored corners. They indicate which cut plane is displayed within this sub tile. Same color signalizes the togetherness of a MPR (= cut plane) and its position (LOIs within MPR respectively plane within the Spatial arrangement of MPRs). A spatial display of the cut planes is only visible at the spatial arrangement of MPRs. This helps the user to get a good impression of a volume dataset during navigating through it. The Spatial arrangement of MPRs always shows the cut planes correspondent to the displayed MPRs.

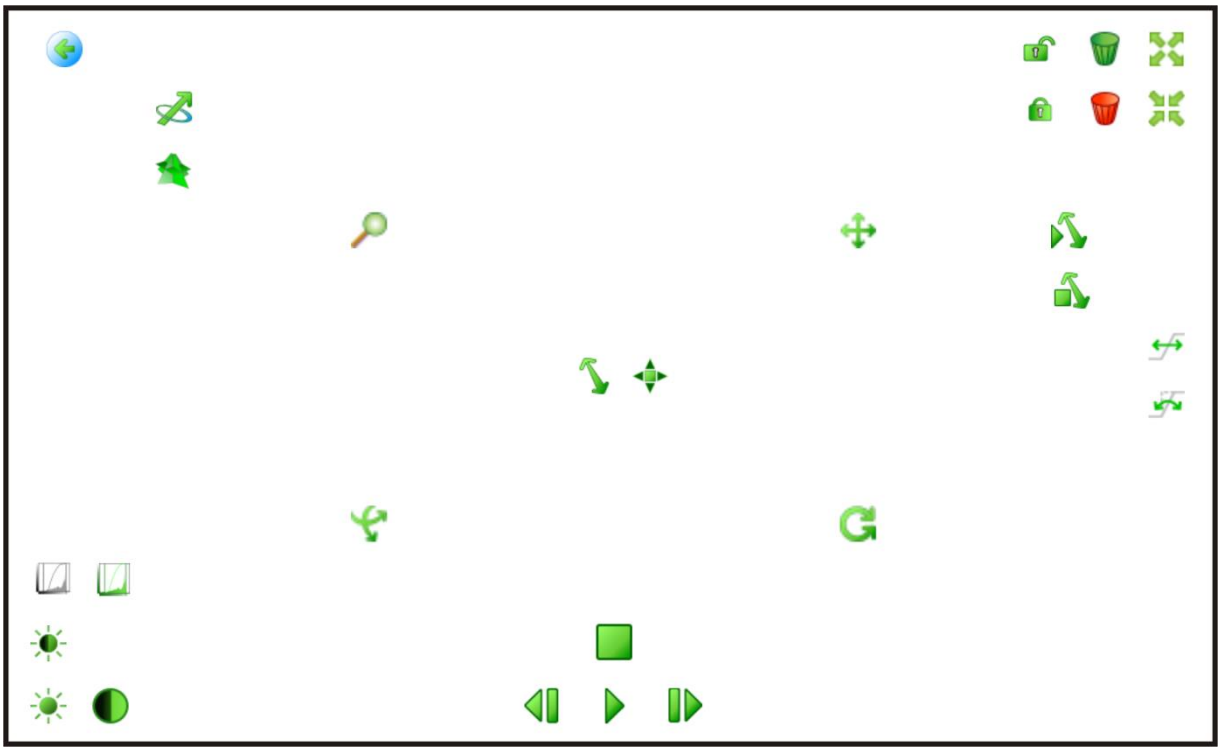
Workspace

Hot regions within a tile

Each tile contains hot regions of special functions. The icons of the correspondent functions are visible by positioning the mouse cursor over a tile for a short time. The number of functions provided within a tile depends on the kind of data, which is displayed there.

There are two ways to use functionalities of hot regions:

- Position the mouse on an icon. Keep the left mouse button pressed and move the mouse horizontally to perform the selected functionality.
- Click on an icon to activate/deactivate its function.



Possible hot regions within a tile

Item	Name	Function
	**Reset**	(local) is only applicable for the content of the tile where it is placed. For information about this function please refer to the chapter 2.1 Main interface elements.
Brightness/Contrast (local) are only applicable for the content of the tile where they are placed.		
	**Bright-ness**	For information about these functions please refer to the chapter 2.5.1 Brightness/Contrast.
	**Contrast**	
Render settings for XA-images The functions Level/Window and VOI are not available at the same time. Depending on the VOI LUT state (On/Off) only the VOI LUT function or the Level/Window functions are available for adjusting XA-images.		
	**Level/ Window**	Keep the left mouse button pressed on this icon and move the mouse up or down to adjust the Level. Keep the left mouse button pressed on this icon and move the mouse to the left or to the right to adjust the Window.
	Shar-pening level	offers edge enhancement in four defined levels. The zero value represents the level "XA sharpening is disabled".
	**VOI LUT**	uses the DICOM information provided with the XA-image for adjusting the VOI LUT (Value Of Interest Look Up Table).
	**Manual Pixel Shift**	allows the user to manually shift the mask frame (DSA mode has to be activated - license depending module)
D'art Navigation is only available for Volume datasets.		
	**D'art™ Naviga-tion and view**	excises an interesting slice out of the Volume dataset (e.g. region of an ASD). Place the D'art Navigation arrow like a distance at an interesting MPR tile. At the 4D Data cube only a slice will remain with a thickness corresponding to the arrow length. Change the length or direction of the arrow by drag and drop at one of the arrows ends (only applicable in the MPR tile).
	**Spatial arrange-ment of MPRs**	toggles the display from D'art view to Spatial arrangement of MPRs.
Navigation Tools Slice, Auto slicing and Orbit are only available for Volume datasets.		

	**Zoom**	Keep the left mouse button pressed and move the mouse to zoom the content of a tile in and out. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
	**Pan**	Keep the left mouse button pressed and move the mouse to relocate the content of a tile.
	**Slice**	Keep the left mouse button pressed and move the mouse to move the selected cut plane in parallel slices backward and forward. A keyboard shortcut can alternatively be used for this function. Please refer to the chapter 12 Table of Keyboard Shortcuts.
 **Start**  **Stop**	**Auto slicing**	starts/stops the animated slicing. This function can be abled/disabled within the settings dialogue.
	**Orbit**	Keep the left mouse button pressed and move the mouse to rotate the selected MPR and the Spatial arrangement of MPRs around its vertical/horizontal axis.
	**Rotate**	Keep the left mouse button pressed and move the mouse to rotate one of the selected default MPRs or the Spatial arrangement of MPRs around the axis perpendicular to the screen.

Threshold/Transparency only applied to the tissue of the Volume dataset.		
	**Threshold Tissue**	separates an object of interest from the background and/or unwanted data (noise). Threshold settings help to define which structures are relevant for the reconstruction of the tissue and which ones are not. Gray values above the adjusted threshold are taken into account for the reconstruction, and gray values below are ignored.
	**Transparency Tissue**	A value of 10 creates a solid surface. Increasing this value the transparency of the tissue is increased too.
LOI navigation is only available for Volume datasets and in the single tiling mode..		
	**LOI rotation**	Keep the left mouse button pressed on this icon and move the mouse to rotate the LOIs (Line of intersection) around the axis perpendicular to the screen located at the cross-over point of the LOIs. All LOIs remain perpendicular to each other.

	**LOI slice**	Keep the left mouse button pressed on this icon and move the mouse to move the selected LOI in parallel slices backward and forward.
	**View direction**	indicates from which side of the data volume the user has a look at the correspondent MPR.
	**Orientation Cube**	shows the scan direction. The scan direction is indicated by two colors. The red side of the Orientation Cube represents the first view and the blue one represents the last view of the acquired dataset.

Playbar Tools (local) are only applicable for the content of the tile where they are placed.

	**Previous frame**	For information about these functions please refer to the chapter 2.1 Main interface elements.
	**Pause**	
	**Play**	
	**Next frame**	

Frame slider

Keyboard shortcuts can alternatively be used for going to defined positions within the Frame slider. Please refer to the chapter 12 Table of Keyboard Shortcuts.

Item, button, slider	Name	Function
	**Frame slider**	It consists of the green Current frame indicator and two white colored position sliders. These items have different functions:
	Current frame indicator	displays the position of the currently displayed frame within a sequence. The numeric representation of this position is displayed on the right side of the End position slider. It runs within the area preset by the Start- and End position slider during the Play mode is enabled. It can be relocated by drag and drop if the animation is stopped. Alternatively the position can be set by moving the mouse wheel.

	Start position slider	The Start- and End position sliders limit the length of the sequence of the corresponding clip. The position of these sliders can be adjusted by drag and drop. The Current frame indicator is set to the new position of the currently relocated slider. In DSA mode (license depending module) the start position slider is automatically set to the first contrast image i.e. the first frame that succeeds the mask frame.
	End position slider	
The following functions are only available (and visible) if a clip contains R-wave tag information.		
	R wave indicator	displays the positions of all R waves within the sequence as yellow dashed lines within the ECG trace. Clicking between two yellow dashed lines selects this R-R wave loop.
	**R-R wave loop selector**	If more than one R-R loop is present in a clip then the loop selector (X/Y) can be used to select a particular loop. Clicking on this icon resets the current view back to default: Show the whole sequence.
	Previous R-R wave loop	decrements the current R-R wave loop selection.
	Next R-R wave loop	increments the current R-R wave loop selection.
Pinning tile content This function is needed for for comparison of images within a study or for side by side comparison of serial studies.		
	Pinned tile content	toggles the status of the tile content between "pinned" and "released": • "pinned" – The tile content is keeps its respective place within the workspace and keeps its respective animation status. • "released" – The tile content is released and can be changed.
	Released tile content	
Magnification of a view of a Volume dataset		
	Magnify	uses the whole tile area to display only the selected view of a dataset in full size.

	**Demagnify**	reduces the size of the currently shown view of a dataset and displays it together with the associated views of the dataset within this tile.

Context menu(right mouse click)	Function
Select a module	starts the selected module and displays there the content of the active tile. After this module was exited Image-Com returns like displayed before starting this module.
Export as DICOM	The original DICOM clip displayed in a tile can be copied to a selectable target location.

2.3 Preview window

It contains datasets displayed as items of the thumbnail preview. All datasets belong to the selected study displayed in the Study list window on the right side. The only exceptions are datasets in a foreign data format. They are not displayed in the Preview Window and cannot be opened by Image-Com.

A preview thumbnail shows the middle frame of a sequence.

 In case of biplane XA images, both datasets are represented by a singular preview thumbnail that contains both middle frames divided by a diagonal line.

The different frames displayed around a thumbnail have different meanings:

- Bright color frame: This item is displayed at the active tile of the Workspace.
- Dark color frame: This item is displayed at a tile of the Workspace, but it is not the active one.

If another study than the active study () is selected, the Preview Window shows datasets of the selected study. The background of the Preview Window changes from black to a colored background.

Differences between using datasets of	**the active study**	**a non-active study**
Displaying datasets of … at the Workspace	without frame and information	surrounded by a light blue frame labeled with study date and time
Displaying datasets of … at the Preview Window	--	the background is highlighted in a light blue color
Performing Measurements within	all available are possible	not allowed
Performing Annotations within	all available are possible	not allowed

Side by side comparison

It is possible to produce a mix with datasets of different studies of the same patient called Side by side comparison.

After opening Image-Com with one of several studies of the same patient, its contents are displayed in the Diagnostic Area of Image-Com. This study is the active one ( ) among the remaining studies of the same patient. The remaining studies are not active ( ) and cannot be set active in this scenario.

If a non-active study is selected in the Study Window for comparison:

- The Preview Window displays the datasets of the currently selected (non-active) study on a colored background.
- The Workspace still displays the objects of the active study. Selecting another study than the active one doesn't affect the content of the Workspace.
- Select datasets of the active study by clicking the Next/Previous buttons.
- A dataset of a non-active study displayed in the Workspace is surrounded with a light blue frame and its study date is displayed as an overlay.
- Only Basic measurements can be performed.

It is always possible to switch between the active study and non-active studies in the Study Window. Dependent on the selected study (active/non active) following options for using the side by side comparison are available:

- Drag and drop a dataset of the selected study from the Preview Window into the Workspace or use alternatively a double click on it.

Item	Function
Scroll over an item (by mouse move)	opens the Temporary preview window. It displays an enlarged preview of an item for a preset time span.
Double click an item	places the selected item within the Tile sequence at the next tile following the currently active one. Or: Point to an item and place it with drag and drop in the workspace.
Context menu(right mouse click)	
Select a module	starts the selected 2D/3D/4D-module with the dataset represented by the preview icon clicked upon. After this module was exited Image-Com returns like displayed before starting this module.
Edit Label	allows to provide a label for a dataset.
Properties	provides information relevant to customer service personnel.

Thumbnail preview	
Item within the thumbnail preview	Description
Green icon at the upper left corner	file type
Green number at the lower right corner	amount of frames of the displayed sequence
White label at the upper middle	acquisition time
White number at the upper right corner	image number
Gray cross	marks a dataset, which cannot be loaded or doesn't have a preview icon.

2.4 Patient Information

Patient Information at bottom of screen shows information essential to identify the patient. The age displayed is the age of the patient at the time the active study was acquired.

2.5 Image Review tab

The Image Review tab  offers information about existing examinations and analyses related to the selected patient. It displays the Study window and the sliders for Brightness and Contrast.

2.5.1 Brightness/Contrast

The sliders for Brightness and Contrast can be applied to all datasets of the active study. The modifications of Brightness/Contrast are not persistent. They are not saved, when exiting Image-Com.

 Brightness and Contrast can be set specific for a single dataset by using the respective hot regions embedded in the tile. Dataset specific brightness and contrast settings will be removed when adjusting the respective values using the sliders.

Toolspace		
	**Brightness**	lightens or darkens the colors equally.
	**Contrast**	adjusts the difference between light and dark tissue as well as light and dark colors.
	Reset Brightness, Reset Contrast	A click on one of their icons resets its slider to the default value.

2.5.2 Study list

It contains all studies related to the patient. Parts of the active study are displayed at the Workspace depending on the selected Tiling mode. Dependent on the system configuration further studies of the selected patient are displayed too.


It is possible to select another study than the active one, but it is not possible to activate another one.

Sorting fields	Function
headers sorting	The first click will sort in ascending and the second click in descending order.
header sizing	Point between two headers and the cursor changes to ⇤‖⇥. Keep the left mouse button pressed and move the mouse to size the header on the left side of the cursor. Double click between two headers to adapt the size of the corresponding left column. After adaptation all items of it will be displayed with their full length.
Archive-status	The color and the shape of the Archivestatus icons expose studies marked with them as active/not active and show the kind of their availability. The shape marks a study as: • Active Study • not active The color marks a study as: • Online GREEN – The contents of this study are immediately available for review.
Date	Date of study creation
Type	The modality contained within the study.
Description	Information from the corresponding DICOM file

Item	Function
Click a study	marks the selected study and displays its contents at the Preview Window. Selecting another study does initially not have an effect to the datasets in the Workspace.

Context menu(right mouse click)	
Select a CAP	CAPs capable of loading a complete study can be started from the study list by right clicking on a study and selecting the CAP from the list of available CAPs.

2.5.3 XA Features

If XA images are displayed special features for visualization are available.

Histogram		
	Histogram	The histogram shows the grey value distribution of the displayed data set. The percentage value in the upper right corner informs about how much frames of the data set have been processed so far. The histogram shows also the position and width of the selected display window (dashed vertical lines). Those lines can be adapted using the mouse cursor. Window width and center can also be adjusted within the histogram by keeping the left mouse button pressed and moving the mouse: up or down to adjust the center position, left or right to adjust the width.
	Logarithmic	if enabled the histogram is displayed using a logarithmic scale.
	Draw bars	if enabled solid bars are drawn instead of a line.
Level/Window		
	Window Center	Use the slider to adjust the window center.
	Window Width	Use the slider to adjust the window width
	**Reset Window Center**	resets the window center position
	**Reset Window Width**	resets the window width.
	**Find Window Center and Window Width automatically.**	The window center and width is automatically adjusted to the histogram.

Digital Subtraction Angiography (DSA) – license depending module

(According to common medical sense,) a diagnosis should be done together with the original XA images.

	**Use currently active frame as mask image.**	Select the currently displayed frame as the mask frame.
	**Subtraction**	Enables/disables the subtraction of the mask frame from the XA images.
	**Summation**	If enabled all differential images from the first to the currently displayed are summed up.
	**Find suitable Pixel Shift.**	Enables a small frame within the workspace window. The image section within this frame is used to automatically find the best pixel shift between the mask frame and the current frame.
	**Reset all Pixel Shift values.**	Resets the pixel shift of the current frame and all subsequent frames.
	Mask frame	displays the number of the frame that is currently selected as the mask frame.
	Pixel shift	displays the pixel shift between mask frame and currently displayed frame.
XA Sharpening		
	Sharpening Level	Use the slider to sharpen the image.

2.6 Measurements tab (license dependent module)

The Measurements functionalities are only available, if Image-Com was licensed before.

The Measurements tab  offers tools for performing measurements in 2D, M-Mode and Spectral-Doppler datasets. For a better overview the Toolspace of the Measurements tab is divided in Basic Measurements and Measurement Packages for different Exam types. The following Exam types are available:

- Echocardiography
- Carotid
- Transcranial
- Lower extremities
- Upper extremities
- Aortic-Iliac
- Abdominal arteries
- Abdominal veins
- Renal

Each DICOM image data set contains also calibration information. The Measurement section of Image-Arena offers only the measurements corresponding to the recognized calibration. Other measurements are not available. Further labeled and unlabeled measurements can be performed in the MPRs of a Volume dataset.

Manual selection of a Basic Measurement or a Measurement Package at the Toolspace

Item	Function
Click a tab (2D, D, M)	offers the available Basic Measurements and medical Measurement Packages.
Click a Basic Measurement	activates the selected Basic Measurement. Move the cursor to the correspondent calibration area within a tile and perform the selected measurement. Succeeding measurements of the same kind can be performed without selection. Terminate this function by selecting another measurement or leaving the Measurements tab.
Click a Measurement Package	selects it. Open with another click a package and select a sub package or a singular measurement. Move the cursor to the correspondent calibration area within a tile and perform this measurement.  The selected measurement can only be performed within tiles their calibration corresponds with it. Other tiles are not accessible for this measurement. Succeeding measurements will be automatically offered (without selection) after having performed the particular measurement before Only applies for specific packages. Other packages will keep the measurement selected such that multiple measurements can be performed. Pressing the key <n> will proceed to the next measurement in a package (if package does not support instances). After having performed all measurements of a measurement package the next offered measurement is the actually active Basic Measurement. But by manual selection single measurements can be called up every time.

Performing measurements:

- A measurement consists of graphical overlay(s) and numerical result(s). The allocation of graphical overlay and correspondent numerical result is provided by indices. Numerical results consist of measured and calculated values.

 Only unlabeled measurements are permanently displayed in the workspace.

- A group consists of packages. A package consists of sub packages and singular measurements.
- The set of numerical values belonging to a package is displayed at the upper left corner of the workspace.
- All numerical values belonging to a sub package and singular measurements are displayed within the tile the measurements were performed.
- Position the mouse cursor over a button of a package the buttons of all corresponding sub packages and singular measurements are highlighted, if there was at least one measurement performed. Further the corresponding graphical overlays are highlighted too and the corresponding values, within the tile the measurement was performed, are displayed.
- Use the ESC key to cancel a measurement process.
- All support points of each measurement can be repositioned by drag and drop.
- Only for Spline, Disks, VTI and PIRI:
  Further support points can be set by clicking on an existing line, define the desired position of a new support point by mouse move and confirm with a second click.
- Multiple measurements: A measurement can be performed up to 5 times. In case this number is exceeded FIFO (First In First Out) will be applied.

Measurements tab

Button	Name	Function
Special buttons for handling measurement packages and measurements		
	**Automatic detection**	generates automatic proposal for otherwise manual user input. This proposal (like e.g. calipers or contours) can be accepted or modified by the user. This function is available, if the respective module for automation was licensed before. Please refer to the chapter 13 Quick Instructions - Automatic Detection Modules.
	**Manual input dialog**	opens a Manual input dialog. Type in the desired value and confirm with OK. These dialog buttons only appear during a call up of some medical Measurement Packages.
	**Show measurement**	displays the dataset and the specific frame of it where the measurement was performed. This function is only available for labeled measurements which were performed in Image-Com. All other measurements imported via DICOM cannot be displayed by this function.
	**Remove package**	removes all graphical overlays and measurement values belonging to the selected medical sub measurement package.

	**Remove input**	removes the last graphical overlay of the selected measurement parameter together with its numerical result at the active (sub) tile. Using the button repeatedly undoes only the measurements of the selected measurement parameter in the reverse order they were created before.
General buttons for measurements		
	**Delete Last Measurement**	removes the last created or activated graphical overlay together with its numerical result at the active (sub) tile. Using the button repeatedly undoes the measurements in the reverse order they were created or activated before.
	**Delete All Measurements**	removes all displayed graphical overlays together with their numerical results at the active (sub) tile.
	**Next Result Position**	toggles between four Result positions within all tiles: • value list beginning at the upper left corner • value list divided into multiple columns distributed over the whole width at the top • value list beginning at the upper right corner • value list divided into multiple columns distributed over the whole width at the bottom
	**Launch Worksheet**	opens the Worksheet display.

2.6.1 Basic Measurements

There are Basic Measurements available for 2D, M-Mode and Spectral-Doppler datasets. The following table describes the handling of them:

2D Measurements

Button	Name	Function
	**Distance**	Click once to define the starting point of the Distance. Finish its placement with a second click in order to define its end point.
	**LV Distance**	This function is used to measure the succeeding distances IVS, LVID and LVPW in one step. Click once to define the starting point of the IVS distance. Define with a second click the border between IVS and LVID. The next click determines the border between LVID and LVPW. Finish this function by determining the thickness of the LVPW.

	**Angle**	The angle is defined by three clicks: the apex followed by two points that define the two sides of the angle.
	**Angle 4Pt**	Position two Distances in this way that they have an intersection point (real or imaginary, when the extension of both distances would lead to an intersection point).
	**Ellipse**	Define with two succeeding clicks the position and length of the first of the orthogonal axes. The third click defines the length of the second axis.
	**Curve**	A sequence of clicks defines points on an open curve. The curve is terminated by a double-click or a right-click.
	**Area**	Click once to define the starting point of the Spline. Circumscribe the interesting region by placing succeeding points. A double-click or a right-click terminates the spline design.
	**Disks**	This function is predominantly used for the circumscription of heart ventricles. The base line lies at the level of the valve connecting an atrium with its ventricle. Starting point and end point define the base line of a circumscription. Click once to position the starting point. Circumscribe the region by placing succeeding points. A double-click or a right-click defines the position of the end point and connects the starting point with the end point. Position the perpendicular axis shown to the base line and fix it with another click.

Spectral-Doppler Measurements

	**Time**	Define with two single clicks the region for the Time measurement.
	Velocity	Define with a click the point at which the velocity should be discovered.
	**Heart Rate**	Define with two single clicks the region for the Heart Rate measurement.
	**Acceleration**	Define with two single clicks the passage at which the Acceleration should be discovered.
	**PHT**	Place with a click the first point at a peak of a graph. The second click determines the gradient of the corresponding falling edge.
	**VTI**	Click once to define the starting point of the integral. Circumscribe the interesting region by placing succeeding points. A double-click or a right-click terminates the circumscribing the integral.

	**PIRI**	Click once to define the starting point of the integral. Circumscribe the interesting region by placing succeeding points. A double-click or a right-click terminates the circumscribing the integral.
	**AC/DC**	Three succeeding clicks describe the AC/DC Rate. The first passage embedded between first and second click represents the acceleration. The second passage embedded between second and third click represents the deceleration.
	**EA Slope**	Define with the first click the position of the E point. The second click defines the end point of the deceleration time. The third click defines the position of the A point.

M-Mode Measurements

	**Distance**	Click once to define the starting point of the Distance. Finish its placement with a second click in order to define its end point.
	**Time**	Define with two single clicks the region for the Time measurement.
	**Slope**	Define with two single clicks the passage at which the Slope should be discovered.
	**LV Distance**	This function is used to measure the succeeding distances IVS, LVID and LVPW in one step. Click once to define the starting point of the IVS distance. Define with a second click the border between IVS and LVID. The next click determines the border between LVID and LVPW. Finish this function by determining the thickness of the LVPW.
	**Heart Rate**	Define with two single clicks the region for the Heart Rate measurement.

2.6.2 Measurement Packages

Image-Com provides measurement packages to well-established measurement procedures. Generally all measured values of the measurements are evaluated by Basic Measurement functions (Please refer to the chapter 2.6.1 Basic Measurements). These measured values are used for the calculation of specific parameters required at a particular medical measurement procedure.

Basic Measurements can simply be assigned to a specific parameter required at a particular measurement procedure:

Perform a right mouse click on a basic measurement value, which is displayed within a tile. A list with special measurement parameters will be opened. The entries of this list depend on the exam type chosen before. Select the desired measurement parameter with a click on

it to assign the basic measurement to it. The value of this parameter will additionally be listed now at the corresponding Worksheet.

Generally all values belonging to a measurement package are listed at the corresponding Worksheet.

For detailed information about measurement packages, please refer to the Technical Specification of Image-Com.

2.6.3 Worksheet and Measurement list

Image-Com provides a Worksheet. It contains all performed measurements (assigned values).

Open the Worksheet display by clicking the Launch Worksheet button. This display shows two tabs:

- **Worksheet**
- **Measurements**

Worksheet		
Items within the header		
Button, Combo box, field	Name	Function
	Exam	displays different examination types. Dependent on the selected type all available packages are shown as a compiled list on the right side of this screen.
	Height, Weight, BSA	Position the cursor within one of these editable fields and type in the needed information.
	Show measured(X)	displays only the packages and sub packages containing at least one value at the packages list. The length of the packages list will be reduced to the amount (X) shown on this button.
	Hide completed(X)	hides only the completed packages and sub packages. The amount (X) shown on this button represents the number of completed sub packages.
	Export measurements	For information about these functions please refer to the chapter 2.1 Main interface elements.

List of packages
It contains packages and sub packages which are assigned to the selected examination type. The packages are shown as boxes.

	Click a package	shows/hides the assigned sub packages.
	Click a sub package	displays the findings record for the selected package.
	**Green tick**	signalizes which sub package is complete. All required measurements and other statements are existent and the correspondent calculations have been performed.
	**Yellow tick**	signalizes which sub package is not complete. This sub package contains at least one value.

Findings record

It consists of chapters, rows, and columns. Each chapter stands for a sub package. Within a chapter the rows represent the possible measurement parameters with their correspondent units. The columns display the values, which are assigned to the particular measurement parameters. The origin of the values can be different:

- result of a measurement
- derived from calculations based on measurement results
- manually typed in

Editable field within an opened Measurement Package		Position the cursor within one of these editable fields and type in the needed information. Afore measured values can be overwritten by manual input. Finish the input with clicking the Enter button. Values manually typed in are labeled with asterisks. Further results out of a calculation with asterisk values are labeled with asterisks too. Calculated values are not (directly) editable.
Method	**Avg/ First/ Last/ Min/ Max/ ***	displays values in the Result column. This display can be toggled between the value types: ❑ average evaluated within a row ❑ first measured/typed in ❑ last measured/typed in ❑ lowest within a row ❑ highest within a row ❑ typed in One average is evaluated for each mentioned Cardiac Measurement. The default setting is Average.
	**Delete this column** **Delete this row**	deletes all entries of this column/row, where this icon is associated to.

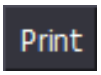
	**Exit**	closes the Worksheet and returns to the Measurements tab of Image-Com. All changes done to the Worksheets will be stored.

Measurements list

Image-Com provides a measurement list next to the worksheet. It gives an overview of all measurement values which Image-Com (i.e. the finding service) holds.

The list consists of a header with Patient ID, Patient Name, DOB, Sex, Height, Weight, Study ID, Study Date and Time (latest modification) and of a body which contains all measurements.

All measurements (including multiplicities) are grouped and sorted by packages analog to the Worksheet. Stress Echo Scores are not displayed and can be accessed only in Echo-Com.

Button	Name	Function
		prints the measurement list natively or as PDF.

2.7 Annotations tab

The Annotations tab  offers tools for placing labels within a dataset. These tools can be used to highlight interesting details inside and to provide quick orientation for the user.

Annotations tab

- Activate the function of Arrow, Annotation, or Anonymize with a click on the correspondent button.
- Terminate these functions by selecting another Annotation tool or leaving the Annotations tab.
- All support points of an arrow and the location of a text can be repositioned by drag and drop.
- Click inside an existing text to edit it.

Button	Name	Function
	**Annotation**	Position the mouse cursor on an interesting detail within the active tile. Type in the desired text and finish editing by pressing the Return key.
	**Arrow**	Position the mouse cursor within the active tile. Click once on an interesting detail to place the base of the arrow. Finish the arrow placement with a second click in order to define the position of its top.
	**Anonymize**	Define with the first click one of the corners of the rectangle which should be drawn. Raise by mouse move the rectangle to its desired size and fix it with a second click. Size and location of an Anonymize rectangle are not editable.

	**Delete Last Annotation**	removes the last Annotation at the active (sub) tile. Using the button repeatedly removes the Annotations in the reverse order they were created before.
	**Delete All Annotations**	removes all Annotations at the active (sub) tile.

2.8 Annex: Basic and Automatic Measurements

Take any information needed about the Basic and Automatic Measurements from the tables below:

Basic Measurements

Button	Basic Measurement	[Unit]	Used in datasets of the acquisition mode(s)	Formula	Measurements accuracy
	**Distance**	mm	2D	n/a	2D ≤ 5%
			M-Mode		M-Mode ≤ 5%
	**LV Dist (Left Ventricle Distances)** The three succeeding distances IVS, LVID and LVPW are lying on one ray. Therefore they can be measured in one step.	mm mm mm	2D	n/a	2D: IVS, LVID, LVPW ≤ 5%
		mm mm mm	M-Mode		M-Mode: IVS, LVID, LVPW ≤ 5%
	**Angle**	° (degree)	2D	n/a	alpha, beta ≤ 5%
		° (degree)			
	**Area**	mm	2D	n/a	Circumf. ≤ 5%
		cm²			Area ≤ 5%

	**Ellipse**	mm	2D	n/a	Circumf. ≤ 5%
		mm			Diameter1 ≤ 5%
		mm			Diameter2 ≤ 5%
		cm²			Area ≤ 5%
	**Disks (Volume evaluated by Method Of Disks)** Method of calculating volume based on the summation of disk volumes.	mm	2D	$= \frac{\pi}{4} \sum_{i=1}^{20} a_i \mathbf{X} b_i \mathbf{X} \frac{L}{20}$ **where a_i, b_i = 20 disks obtained from A4C and A2C**	Circumf. ≤ 10%
		cm²			Area ≤ 10%
		mm			Diameter ≤ 10%
		cm³			Volume ≤ 10%
	**Time**	ms	M-Mode	n/a	no deviation
			Spectral-Doppler		
	**Velocity**	m/s mmHG	Spectral-Doppler	0,0004 * velocity * velocity	no deviation
	**Heart Rate**	bpm ms	M-Mode	minute / time	no deviation for HR, Time / cycle
			Spectral-Doppler		
	**Acceleration**	m/s ms ms m/s²	Spectral-Doppler	n/a	no deviation for Accel, Time, Velocitymax
	**PHT (Pressure Halve Time)**	m/s ms ms m/s²	Spectral-Doppler	n/a	no deviation for Velocitymax, PHT, Time, Slope
	**VTI (Velocity-time Integral)**	cm ms ms m/s²	Spectral-Doppler	n/a	no deviation for VTI, Velocitymax, PGmax, PGmean
	**PIRI**	WI=[ ] PI=[ ] PS=m/s MD=m/s S/D=[ ] TAmx=m/s	Spectral-Doppler	RI = (Vmax - Vmin) / Vmax PI= (Vmax - Vmin) / Vmean PS = Vmax MD = Vmin S/D = Vmax / Vmin TAmx = Vmean = VTI / Duration	no deviation

	**AC/DC (Acceleration/Deceleration Rate)**	m/s² ms m/s² ms	Spectral-Doppler	n/a	no deviation for AR, AT, DR, DT
	**Slope**	ms mm m/s	M-Mode	distance / time * 0,01 * 1000	no deviation for Time, V

Measurement Packages

The measurement accuracy of the Measurement Package Values is analog to the according Basic Measurement. In case of a formula it depends on the single elements of the formula. No additional deviation caused by the formula.

For detailed information about the Measurement Packages, please refer to Technical Specification of Image-Com.

3 4D LV-Analysis© 3.1 4D LV-Function™ 3.1

3.1 Quick Guide

This chapter introduces the GUI structure of the application and presents an exemplary workflow.

3.1.1 Frame Rate

Datasets have to be acquired with a minimum frame rate of 10 frames/heart cycle.

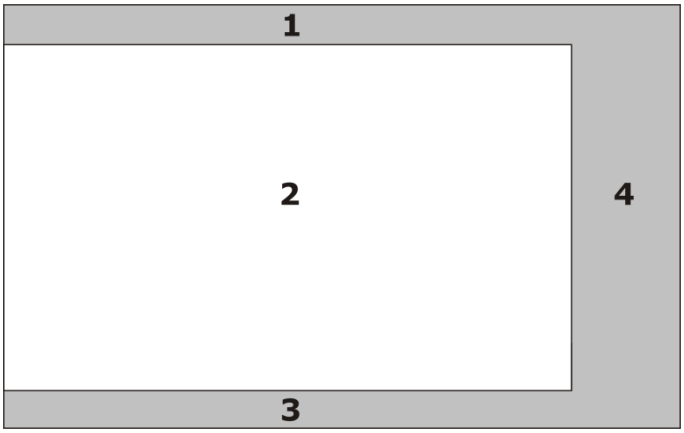
3.1.2 Data Cropping

In case the dataset includes more than 1 heart cycle, the application automatically crops the data back to one heart cycle according to following conditions:

1.) Only the last heart cycle of a multiple heart cycle dataset will be used for analysis of Toshiba Artida datasets. For all other datasets, the first heart cycle will be used.
2.) The displayed data last from the 1st R-wave to the 2nd R-wave within the dataset.
3.) If 2.) is not possible, first frame is taken as start frame, mean R-R-duration is used to estimate length of heart cycle.
4.) If 3.) is not possible, dataset is taken as it is.

3.1.3 Main Interface Elements

This section presents a general overview of the main interface elements.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Workflow/ Toolspace**	A top down workflow, which guides the user through review and measurement of his examination. At particular workflow steps the Toolspace offers special functions for analysis and measurement.

To get instant help on working with the software first open the **About** box  and then click on the **Help** button to open the manual of the application.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

3.1.4 User Workflow

CAP Start

- Start the platform software (e.g. Image-Arena)
- Select a 3D/4D study
- Select a 4D dataset within the preview window
- Press the right mouse button and select 4D LV-Analysis or 4D LV-Function to start the application

View Alignment

Aim: Manual adjustment of automatically detected axes.

1.) **Adjust MV – Apex axis.** Select one of the standard views. Reposition one of the axis endpoints by drag and drop. Position the landmarks (MV-Mitral valve, Apex) as described in the following:

- MV – Place this landmark at the annulus level in the middle of the MV.
- Apex – Place this landmark at the apex.

Each landmark reposition results in a change of all MPRs. Redo the adjustments in each LAX MPR until the positions of the landmarks (MV, Apex) are correct in each standard view.

Modifying the axes will delete an already existing surface model!

Use the Flip LAX View Orientation button  to flip the views upside down in case of TEE data.

2.) **Define AV orientation.** Keep the left mouse button pressed on a LOI slice icon in the A3Ch view and move the mouse to find a level of the SAX plane, which represents the AV (AV – Aortic valve) best. Place the landmark AV shown within the SAX view at the valve level in the middle of the AV.

3.) **Define reference frame for tracking.** Tracking is usually initialized with the end-diastolic frame. If necessary, position the green bar at a preferred position within the heart cycle range in order to define this frame as Reference frame for tracking and click on the Set Reference Frame button  .

4.) Click on the Beutel Revision button to enter the next step.

Beutel Revision

Aim: Modification of the static initial surface model of the left ventricle. The Beutel calculation was performed on the basis of the enddiastolic or reference phase (if a reference frame has been defined manually). The modifications can be done to each contour displayed in static long axis and static short axis views.

1.) **Check the static 3D LV model.** Check the model contours vs. the anatomy displayed as MPRs and/or 3D. Use for this purpose the functions LOI slice and Orbit (only 3D view).

2.) **Edit the 3D LV model contours.** Use the tools provided in the toolspace sections: Edit mode providing different pen sizes. These tools can be applied in every LOI position. Modifications can only be done within the static MPR tiles.

3.) Click on the Tracking Revision button to enter the next step.

Tracking Revision

Aim: Display of the automatically calculated 3D surface model of the left ventricle (Beutel) and its derived contours. The dynamic Beutel can be modified by contour changing at the ED or ES frame.

1.) **Check the dynamic 3D LV model.** Check the model contours vs. the anatomy displayed as MPRs and/or 3D view in ED and/or ES. For this purpose use the functions LOI slice, Orbit (only 3D view) and the Edit ED/ES layout options.

2.) **Edit the 3D LV model contours.** Use the tools provided in the toolspace section Pen Size. These tools can be applied in every LOI position, if the sequence animation has been previously stopped.
Editing the contours will alter the displayed function parameter values displayed in the upper left image region.

3.) You may add an epicardial contour by clicking on the Add Epicard button  in order to calculate the LV mass. The epicard contour can be edited as described in 2.) above.
4.) Click on the Analysis button to enter the next step.

Analysis

Aim: Display of different parameters derived from the dynamic surface model of the left ventricle. These parameters are displayed as text results for the following ones:

- **EDV**: End-diastolic volume
- **ESV**: End-systolic volume
- **SV**: Stroke volume
- **EF**: Ejection fraction
- **Mass**: Left ventricular mass
- **GLS**: Global longitudinal strain
- **GCS**: Global circumferential strain

For the corresponding formula and precision refer to chapter 3.2 Annex: Measurements.

On the right hand side of those parameters a chart displays the global volume-time curve corresponding to the dynamic Beutel.

By clicking on the Segmental Volumes button  the chart will display the segmental volume-time curves according to the ASE 16 segments model.

Save Results

- **Save Image/Clip** 
  Click this button in the toolbar to export the content of the workspace to a user selectable target directory.
- **Save Secondary Capture** 
  Click this button in the toolbar to store the content of the workspace to the database of the data management platform.

 In both cases you will export a still frame, if the sequence animation has been stopped or a video if the animation is on.

Exit 

Click this button to close the application and return to the data management platform.

The system asks, if the results should be stored as a structured report to the data management platform.

Additional parameters for 4D LV-Analysis option

Aim: Display of additional parameters (e.g. deformation imaging) as global or segmental text results, segmental time curves and static or dynamic parametric maps.

For details about global and regional parameters refer to chapter 3.2 Annex: Measurements.

Parametric maps are applied to the tracked surface model of the left ventricle (Beutel) and to the Polar plot. They are available as dynamic maps and as static delay maps (time-to-peak maps). Further parameter values are aggregated into segmental time curves and some important measurement values.

- **Export Beutel** 
  The tracked LV Beutel mesh can be exported for further analysis. The format is a point triangle mesh: .txt header file with number of frames, vertices and triangle as well as timestamps information. One .ucd-file with the coordinates for every frame in the cardiac cycle.
- **Export Results**  opens the export results dialog.
  Mark the parameters required for the export and click Save. The data are exported as .txt-file.

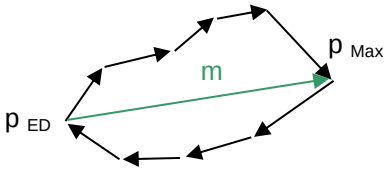
3.2 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Automatic Measurement	[Unit]	Description	Formula	Deviation RMS
Global Analysis (4D LV-Analysis / 4D LV-Function)				
EDV	ml	End-diastolic volume	Maximum volume of global time volume curve	<10% rel.
ESV	ml	End-systolic volume	Minimum volume of global time volume curve	<10% rel.
SV	ml	Stroke volume	SV=EDV-ESV	<10% rel.
EF	%	Ejection fraction	EF=SV/EDV*100%	<10% rel.

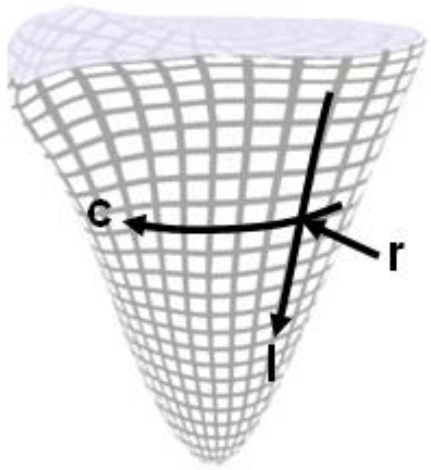
Mass	g	Left ventricular mass	Myocardial volume in ES multiplied by the density 10.055g/cm^3 Myocardial volume is calculated from a connection between the epicardial and endocardial surface model mesh	<10% rel.
GLS	%	Global longitudinal strain	Global shortening of surface model longitudes	<1.0% abs.
GCS	%	Global circumferential strain	Global shortening of surface model latitudes	<1.0% abs.

Automatic Measurement	[Unit]	Description	Formula	Deviation
Additional parameters (only 4D LV-Analysis)				
Global Analysis				
Twist	°	Difference between apical and basal Rotation	Twist = Rotapical – Rotbasal	<5° abs.
Torsion	°/cm	Twist normalized to LV length	Twist/ED length	<0.5°/cm abs.
GLS (average segmental)	%	Longitudinal strain values of all segments are averaged		<1.0% abs.
GCS (average segmental)	%	Circumferential strain values of all segments are averaged		<1.0% abs.
GRS (average segmental)	%	Radial strain values of all segments are averaged		<1.0% abs.
Regional Analysis				
Longitudinal displacement	mm	Motion component in the longitudinal direction of the LV coordinate system. *		<1mm abs.
Circumferential displacement	mm	Motion component in the circumferential direction of the LV coordinate system. *		<1mm abs.
Radial displacement	mm	Motion component in the radial direction of the LV coordinate system.*		<1mm abs.

3D displacement	mm	Movement vector from surface point position in ED to current surface point position projected to the direction of the longest of all such movement vectors for this surface point. The positive direction is apical inward.	 m direction of maximal movement p Max position of maximal movement p ED end diastolic position	<1mm abs.
Rotation	°	Rotation around the long axis. The positive direction is counter clockwise viewed from apex to base. *		<3° abs.
Longitudinal strain	%	Strain in the longitudinal direction of the LV coordinate system from the end-diastolic frame.	$\varepsilon_l = \frac{l - l_{ED}}{l_{ED}}$	<2.5% abs.
Circumferential strain	%	Strain in the circumferential direction the LV coordinate system from the end-diastolic frame.	$\varepsilon_c = \frac{c - c_{ED}}{c_{ED}}$	<2.5% abs.
Radial strain	%	Strain in the radial direction of the LV coordinate system.	This value is estimated from the longitudinal and circumferential strain under the assumption of incompressibility of the cardiac wall.	<2.5% abs.
Principal tangential strain	%	Strain in the direction of the greatest elongation/shortening in a plane tangential to the surface.	It is calculated from longitudinal and circumferential strain using singular value decomposition.	<2.5% abs.

* The values for longitudinal, circumferential, and radial displacement are accumulated from a frame to frame displacement, measured in a local coordinate system on an interpolated model. Accumulation starts with the end-diastolic frame.

Definition of the LV coordinate system



l **Longitudinal direction:**

- Tangential to the LV surface in the projected long axis direction.
- The positive direction is towards the apex.

c **Circumferential direction:**

- Tangential to the LV surface and around the long axis
- The positive direction is counter clockwise viewed from apex to base.

r **Radial direction:**

- Perpendicular to the LV surface
- The positive direction is inward.

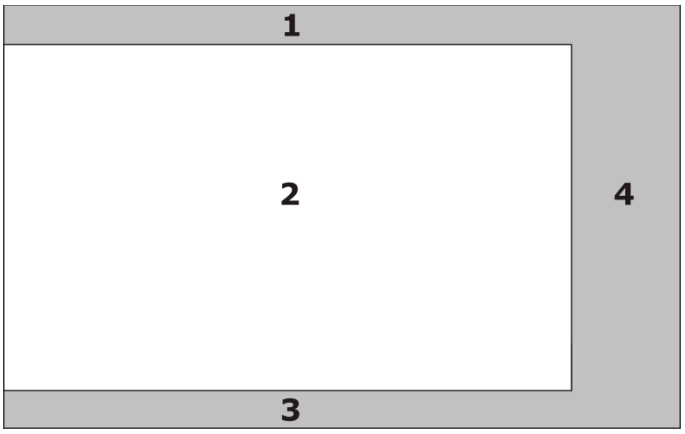
4 4D RV-Function© 1.2

4.1 Quick Guide

This chapter introduces the GUI structure of the application and presents an exemplary workflow.

4.1.1 Main Interface Elements

This section presents a general overview of the main interface elements.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Workflow/ Toolspace**	A top down workflow, which guides the user through review and measurement of his examination. At particular workflow steps the Toolspace offers special functions for analysis and measurement.

To get instant help on working with the software double-click on its manual icon on the desktop.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

4.1.2 User Workflow

Starting 4D RV Function

4D RV-Function is started from Host System. 4D RV-Function immediately starts with the Selected Image or the user has to select the Selected Image or an available Bookmark before. Position the mouse pointer on an item, open the context menu with a right mouse click and select 4D RV-Function.

View Adjustment

1.) **Select the acquisition direction.** Select the suitable entry at the Acquisition Window, describing the direction of the ultrasound transducer at the acquisition.

2.) **Adjust MPR views before setting a Landmark.** Normally the loaded dataset will be displayed with well represented MPR views. But the user can adjust these representations to his conceivabilities. Use:

- **Pivot/Orbit.** Left click and hold on an axis circle  to rotate a selected Cut Plane.
- **Pan.** Right click and hold on a tile to relocate its MPR.
- **Slice.** Left click and hold on double arrows  at the right side of a horizontal dashed line to slice along the long axis of the heart.

3.) **Set Landmarks (LM).** Three Landmarks have to be set at the Sax tile.

- **LM in center of TV and MV.** Adjust Sax view like displayed in figure.
- **LM in apical region of LV.** Adjust Sax view like displayed in figure 2.

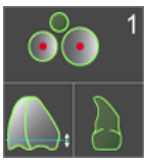


figure 1

figure 2

4.) **Check the definition of Enddiastole/Endsystole.** Normally the loaded dataset will have two frames determined for them (red/blue marker inside the Frame slider). Using the **Set ED**/**Set ES** buttons the user can define other frames within the sequence.

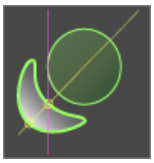
Set Initial Contours

1.) **Set Initial Contours (4Ch, Sagittal, Coronal).** Use the static views (endsystolic/enddiastolic) for contour tracing. Place the first point of the contour spline with a click within one static image. Trace the contour (green) and define the position of the last spline point with a double click (or right mouse click). Redo this on the other static images.

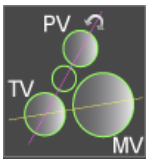
2.) **Select the next Set Initial Contours Workstep.** The Sagittal and Coronal views show yellow circles with center points. These marks serve as support points for the determination of the contour to be traced. This contour has to intersect these circles at least. Proceed like described before until all contours are defined.

3.) **Coronal view.** Before performing a contour tracing in this view please check the position of the dashed magenta line at the upper left tile against the figure 6a. If the result is OK, proceed with contour tracing here. If not, grab this line with a mouse click on it and reposition it like shown in figure 6a.

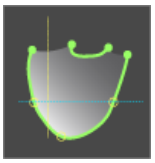
A4Ch view
figure 4



Sagittal view
figure 5



Coronal view
figure 6a



Coronal view
figure 6b

Contour Revision

1.) **Check evaluated contours vs. real anatomical structure of RV:**

- **Slice within the A4Ch, Coronal tile.** Left click and hold on double arrows  at the right side of a horizontal dashed line to slice through the RV cavity.
- **Slice within a Sagittal tile.** Left click and hold on a tile to slice through the RV cavity like described before.
- **Pan within all tiles displayed.** Right click and hold on a tile to relocate its MPR. This function affects images shown within other tiles too.

2.) **Adapt evaluated contours.** Use the Contour Detection Sensitivity 
and/or the Beutel Editing Tools  to adapt the evaluated contours to your conceivabilities.

3.) **Review the displayed Beutel.** Use the Show Beutel View  button for displaying the evaluated Beutel.

- **Pivot**: Left click and hold to rotate the Beutel around its axes.
- **Pan**: Right click and hold to relocate the Beutel.

Beutel Analysis

1.) **Review the displayed Beutel.**

- **Pivot**: Left click and hold to rotate the Beutel around its axes.
- **Pan**: Right click and hold to relocate the Beutel.

2.) **Compare Beutel motion vs. course of the Global Volume graph.** Use the Playbar Tools and Go To Enddiastole/Endsystole buttons to display interesting frames of the Beutel.

Storing reworked study

Use the Bookmark  , Export Measurements  and Export AVI/BMP  buttons to save the results of your reworked study. Exit 4D RV-Function by clicking the Exit  button.

4.2 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Automatic Measurements

Measurement as displayed in the settings	Measurement as displayed in the numeric result window of the analysis screen	Unit	Description	Meaure-ments accuracy
EDV End-diastolic Volume	EDV	ml	End-Diastolic Volume	Deviation < 10%
ESV End-systolic Volume	ESV	ml	End-Systolic Volume	Deviation < 10%
SV Stroke Volume	SV	ml	SV=EDV-ESV	Deviation < 10%
EF Ejection Fraction	EF	%	EF=SV/EDV*100%	Deviation < 10%

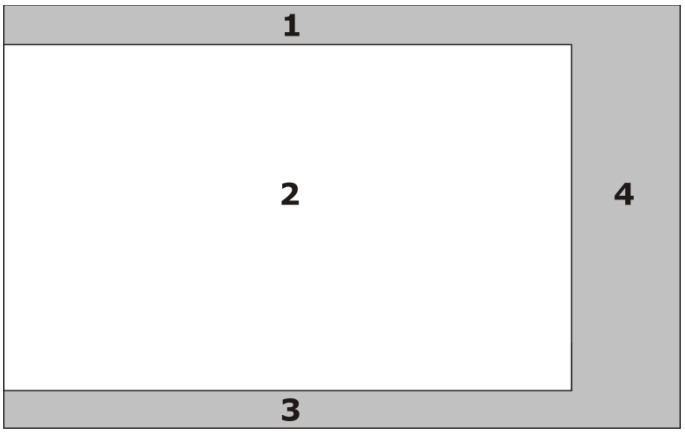
5 4D Cardio-View™ 3.0

5.1 Quick Guide

This chapter introduces the GUI structure of the application and presents an exemplary workflow.

5.1.1 Main Interface Elements

This section presents a general overview of the main interface elements.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Workflow/ Toolspace**	A top down workflow, which guides the user through review and measurement of his examination. At particular workflow steps the Toolspace offers special functions for analysis and measurement.

To get instant help on working with the software first open the **About** box  and then click on the **Help** button to open the manual of the application.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

5.1.2 User Workflow

CAP Start

1.) Start the platform software (e.g. Image-Arena).
2.) Select a 4D dataset within the preview tab.
3.) Press the right mouse button and select **4D Cardio-View 3** to start the software.

Show anatomical structures

D'art an example of ASD dataset

Aim: Visualization of any 3D structure in a very intuitive way with just two clicks.

1.) Select the 3 MPR + 3D layout.
2.) Look for a 2D view where the ASD can be detected.
3.) Click on the **D'art**  button and set two points (first in RA and second in LA) within the determined 2D view. These points define a region of interest and the viewing direction for the 3D view (volume rendering in the lower right tile).
4.) Grab the volume within the lower right tile and turn it around to see the ASD also from the opposite side.
5.) The thicker the slice is defined by the D'art, the more tissue is displayed in the volume.

Multi slice an example of a LV dataset

Aim: Cutting a selected region in several planes e.g. to review the wall motions in different short axis.

1.) Select a LV dataset.
2.) Select a 2Ch view and click on the **Multi slice**  button in the Toolbar.
3.) The image is displayed in maximum size.
4.) Select the apex as start point and the MV as end point of the area which shall be sliced.
5.) The Software displays the defined area as parallel cut planes with equal distances.

Navigation

- Use the hot regions (**Pivot/Orbit**; **Rotate**; **Pan**; **Slice**; **Zoom**) to navigate the MPR views.
- Or use the **LOI navigation** to align the MPR views.

Basic Measurements Tools 

These tools are used for adding different measurements to a MPR and / or 3D. Animation will automatically stop when performing measurements.

There are different basic measurements like **Distance**, **Area**, **Curve,** and **Angle**.

The end points of the distance line are changeable by drag and drop.

Left Ventricle Volume Measurements

Aim: Calculation of end-diastolic / end-systolic volume, ejection fraction, stroke volume, and mass of the left ventricle.

View adjustment

1.) After entering the **Left Ventricle Volume** state the software aligns the dataset with default orientation.
2.) Redefine the end-diastolic and end-systolic frame by searching for the corresponding frame and selecting it by the corresponding **Set end-diastole**  / **Set end-systole**  button. ED and ES are marked as blue flags within the frame slider.
3.) Use **LOI navigation** to position the SAX at any level to help finding the AV orientation.
4.) Position the 'Apex' and 'MV' in the LAX view and the 'AV' in the SAX view.
5.) Use the mouse-wheel to zoom (mouse help for the zoom can be switched out in the **Settings**  dialogue)

Setting initial contours

1.) Draw at least two open LV contours for each phase.
2.) Optionally can be selected: **Add epicard to end-systolic contour**.
3.) The system automatically lists all results which can be calculated with the input.
4.) Change the contours by drag and drop.

Analysis

1.) Adjust contours by drag and drop if required.
2.) Use **LOI**s to navigate through views.
3.) Change the Pen size  .
4.) The display of results and Beutel will simultaneously be adjusted.
5.) Results are:

- End-diastolic Volume (EDV)
- End-systolic Volume (ESV)
- Ejection Fraction (EF)
- Stroke Volume (SV)
- LV Mass

The calculated volumes can be displayed together with the tissue within the Review  tab.

Generic Volume Measurements

Aim: Calculation of generic volume of any structure (atrium, tumors...).

View adjustment

1.) After entering the **Generic Volume** state the software aligns the dataset with default orientation.
2.) Search the frame which represents the interesting structure best.
3.) Use hot region navigation to position the volume of interest in the center point.

Setting initial contours

1.) Draw at least two closed contours.
2.) Close each contour with a double click.
3.) Change the contours by drag and drop.

Analysis

1.) Adjust contours by drag and drop if required.
2.) Use **LOI**s to navigate through views.
3.) Change the Pen size  .
4.) The display of result and Beutel will simultaneously be adjusted.
5.) Results is:

- Generic Volume (GV)

The calculated volume can be displayed together with the tissue within the Review  tab.

Exiting the application

Click the **Exit**  button to return to the Data Management Platform and to store automatically volume measurements to the database.

5.2 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Basic Measurements

All measurements performed within the 3D view are projected to a 2D plane.

Basic measurement	[Unit]	Description	Formula	Maximum allowed absolute deviation
Distance	mm	Measures a distance between two defined points within a MPR (or 3D View). Points can be repositioned by drag and drop.	n/a	< 5%
Area and circumference	cm^2 and mm	Calculates an area and circumference defined by a spline within a MPR (or 3D view). Points can be repositioned by drag and drop. Add a point to the spline with a left-click on the line between two points.	n/a	< 5%
Curve	mm	Calculates the length of a curved line consisting of a certain amount of points within a MPR (or 3D view).	n/a	< 5%
Angle	° (degree)	Calculates an angle (3 points) defined within a MPR. Angle legs and the center of rotation can be repositioned by drag and drop.	n/a	< 5%

Automatic Measurements

Automatic Measurement	[Unit]	Description	Formula	Maximum allowed absolute deviation
EDV	ml	End-diastolic volume	Volume mesh ED	< 10%
ESV	ml	End-systolic volume	Volume mesh ES	< 10%
SV	ml	Stroke volume	SV=EDV-ESV Manually calculated results are equal to software calculated results (rounding error in the last displayed digit accepted)	< 10%
EF	%	Ejection fraction	EF=SV/EDV*100% Manually calculated results are equal to software calculated results (rounding error in the last displayed digit accepted)	< 10%
LV Mass	g	Left ventricular Mass	LV Mass = (Volume Epicardium - Volume EDV) * 1.055 g/ml LV myocardial density = 1.055 g/ml	< 10%
GV	ml	Generic volume	Volume mesh	< 10%

6 4D MV-Assessment© 2.3

6.1 Quick Guide

This chapter introduces the GUI structure of the application and presents an exemplary workflow.

6.1.1 Data Formats

The software is merely intended for TEE and TTE 3D ultrasound data, clips containing at least 3 frames/heart cycle.

Supported data formats:

- Philips iE33 and CX50 TEE and TTE (inclusive wide angle data with a high frame rate): full volume, Live3D, zoom data
- GE TTE and TEE VolDICOM data (and DICOM data if available)
- Siemens Toyon SC2000 TTE
- Toshiba Artida 2.x and 3.x Single and Full Volume Clips

Color and tissue data can be imported if available.

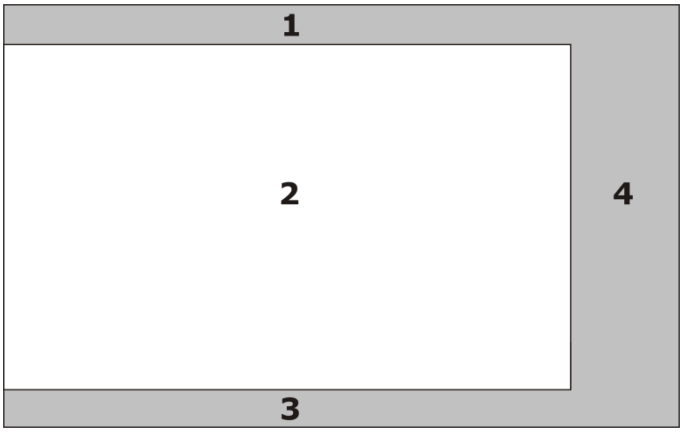
No image compression algorithms are used for image visualization.

6.1.2 Frame Rate

Datasets have to be acquired with a minimum frame rate of 3 frames/heart cycle.

6.1.3 Main Interface Elements

This section presents a general overview of the main interface elements.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
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6.1.4 User Workflow

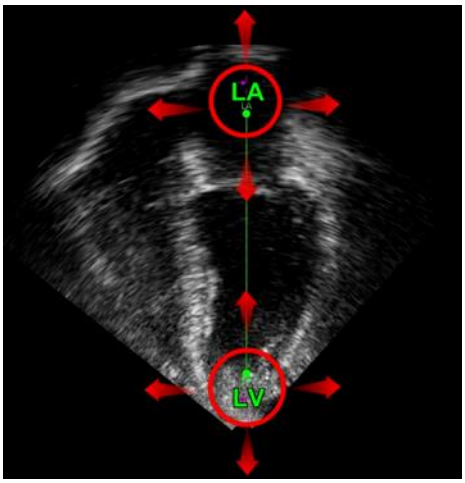
CAP Start

- Start the platform software (e.g. Image-Arena 4.3)
- Select a 3D/4D study which supports the 4D MV-Assessment CAP
- Go on the Preview tab and select a 4D dataset
- Press the right mouse and select "4D MV-Assessment 2" to start the software

Initial Orientation

Aim: Initialization of the dataset in order to automatically adjust it.

1.) **Adjust long axis.** Verify if the data set is orientated correctly. The left atrium should be above the left ventricle.
The application offers the opportunity to manually adjust the view by axis navigation. Both endings of an axis can be replaced by drag and drop to straighten the long axis. The views will be reoriented accordingly.

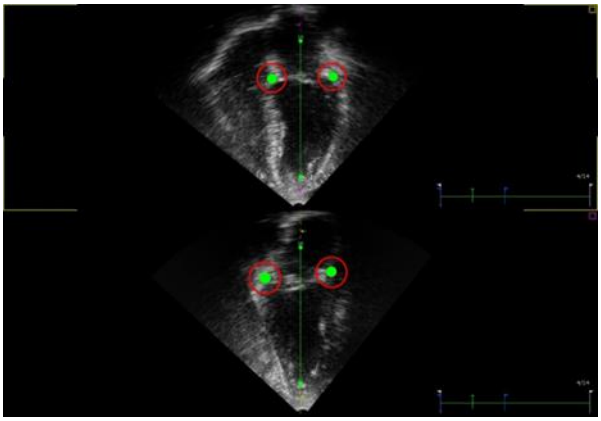


2.) **Set frame of interest.** Stop the animation of the clip. Use the playbar tools   to define the systolic range of the cardiac cycle (if necessary). Position the green bar at the end-diastolic frame and click on the "Set End-Diastole" button  . Move the green bar to the end-systolic frame and click on the "Set End-Systole" button  . At this frame the mitral valve (MV) has to be closed.

3.) **Set MV annulus landmarks.**
Position the green bar in the middle of the systolic range.

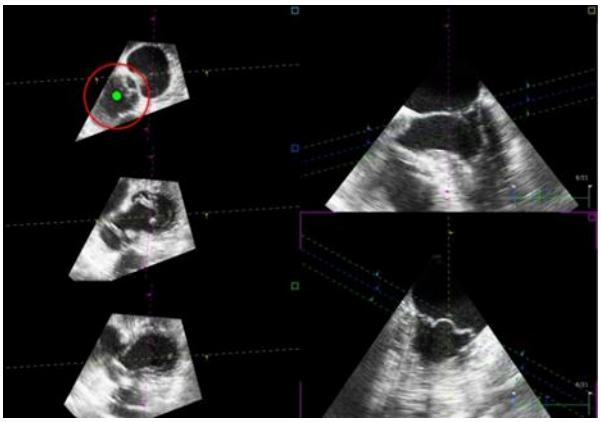
Define the position of the mitral annulus by setting two landmarks (LMs) in the upper LAX view and two in the lower LAX view.

The display changes from the dual layout to the Vertical 3 + 2 layout and the animation of the clip is started.



4.) **Set LVOT LM.**
Select one of the three SAX views (on the left side) in which the left ventricle outflow track (LVOT) is seen well.

Set a landmark (LM) in the middle of the LVOT in order to define the orientation of the 3Ch view.



View Adjustment

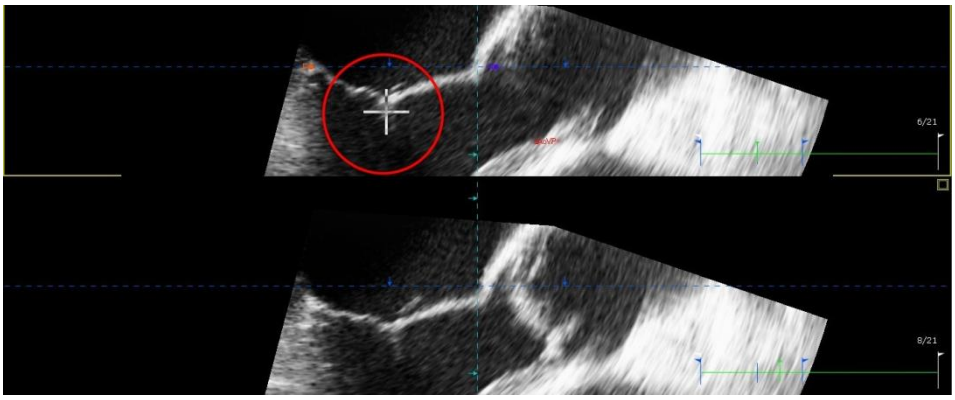
Aim: Verification and correction (if necessary) of the 3Ch view which was determined the step before. Further the diameter of the aortic valve annulus can be defined.

1.) **Set line of interest.** Keep the left mouse button pressed on a LOI slice icon in the upper tile and move the mouse to find a level of the SAX plane, which represents the best 3Ch View.
2.) **Adjust the 3Ch view.** Keep the left mouse button pressed on a LOI rotation icon in the lower tile and move the mouse to align the LOI to the center of the aortic valve. If the following step should be skipped please click on the "Set reference points" button.
3.) **Set aortic annulus (if required).**  Click the "Set the apical aortic annulus point (aAoA)" button. The display changes from dual layout to single layout and the animation of the clip is stopped. Set a landmark (LM) in order to define the apical aortic annulus point. This step is required to get a ring model of the aortic annulus displayed later.

Set Reference Point

Aim: Setting of coaptation landmark(s) which will trigger the automatic detection of both leaflets.

Set landmark(s) at the end of the coaptation. Watch the animated middle tile and set a landmark (LM) at the upper static tile in order to define the end of the coaptation of the mitral valve. The lateral view of the anterior (blue) and the posterior (red) leaflet are represented by lines.

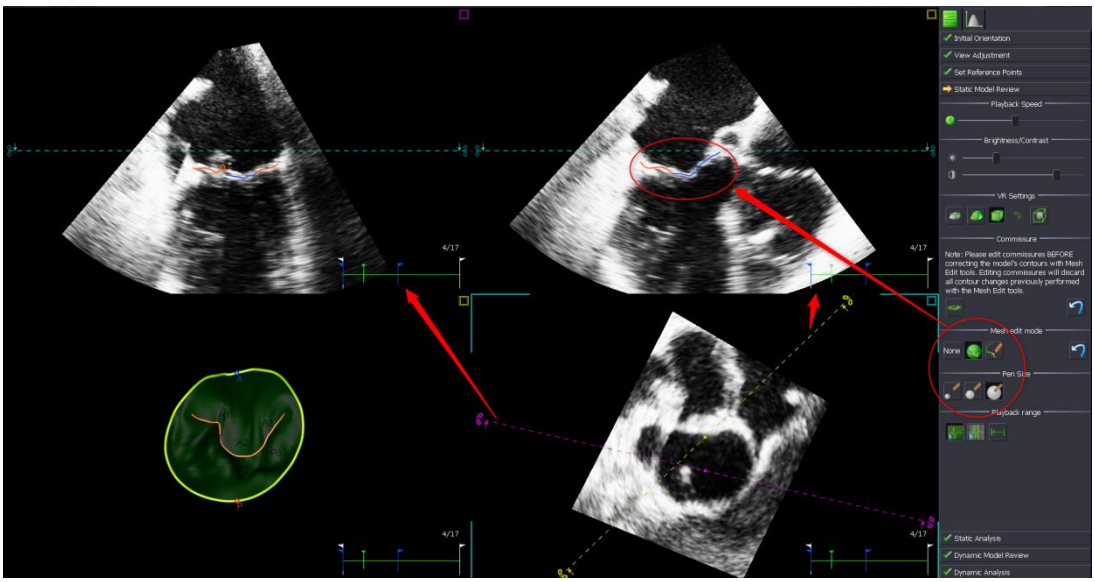


Static Model Review

Aim: Review and correction of automatically detected leaflet contours.

1.) **Check the 3D MV model.** Stop the animation of the clip. Check the evaluated 3D model of the mitral valve vs. its real anatomy according to the ultrasound images displayed as MPRs and 3D. Use for this purpose the functions LOI slice, LOI rotation and Pivot/Orbit (only available in 3D views).

2.) **Edit the 3D MV model contours.** Use the tools provided in the toolspace sections "Mesh Edit Mode" and "Pen Size". These tools can be applied in both upper long axis views. Each of the long axis views correspond to one of the LOIs in the SAX view (see following figure). Each LOI rotates around its own point of rotation. The yellow LOI and its corresponding upper right MPR fits best for adjusting the coaptation and leaflet contours. The turquoise LOI and its upper left MPR view are best suitable for editing the annulus contour.



3.) **Edit commissures.** Click on the "Edit the position of the commissures" button to activate the edit commissure tool. The display changes from the mixed triple layout to the vertical dual layout (two 3D views) and at the right tile the animation of the clip is started. Use the render tools provided at the Tools tab to create a clear and detailed

representation of the MV coaptation. Replace the position of the commissures with single clicks.

4.) Click on the "Static Analysis" button to enter the next step.

Static Analysis

Aim: Review of MV geometry, associated measurements automatically generated by the system, and special measurements, which can be performed by the user.

1.) **Show result layout**  . It's only for review.

2.) **Show 5-tile layout**  . Use the LOI rotation tool to position up to three different cut planes within the 3D tile for displaying specific details. The three upper tiles represent the MPRs of the cut planes defined in the 3D view.

3.) **Show D'art layout**  . Use the D'art™ tool  to reduce the 3D to a size which only contains the details interesting for an analysis.

4.) **Show Planimetry**  . Use the provided LOIs in the MPRs views to get arbitrary intersections for placing manual measurements (e.g. the opening area of a stenotic valve during diastole).

5.) Use the measurement tools for performing user defined measurements on MPRs.

6.) Click on the "Dynamic Model Review" button to enter the next step.

Dynamic Model Review

Aim: Review and correction of automatically detected leaflet contours on all frames of the systolic range.

1.) **Check the calculated 3D MV model.** Stop the animation of the clip. Check the evaluated 3D model of the mitral valve (MV) vs. its real anatomy displayed as MPRs and 3D. Use for this purpose the functions LOI slice, LOI rotation and Pivot/Orbit (only 3D).

2.) **Edit the 3D MV model contours.** Use the tools provided in the toolspace sections "Mesh Edit Mode" and "Pen Size".
The editing tools can be applied in both upper long axis views. Each of the long axis views correspond to one of the LOIs in the SAX view (see figure in Static Review State). Each LOI rotates around its own point of rotation. The yellow LOI and its corresponding upper right MPR fits best for adjusting the coaptation and leaflet contours. The turquoise LOI and its upper left MPR view are best suitable for editing the annulus contour.

3.) Use the Playbar tools to step through all frames of the systolic phase (in which a model of the MV exists) and evaluate or edit the model as described in the previous step.

4.) Click on the "Dynamic Analysis" button to enter the next step.

Dynamic Analysis

Aim: Review of MV geometry, associated measurements automatically generated by the system, and manual measurements, which can be performed by the user.

1.) **Show result layout**  . It's only for review.

2.) **Show 5-tile layout**  . Use the LOI rotation tool to position up to three different cut planes within the 3D tile for displaying specific details. The three upper tiles represent the MPRs of the cut planes defined in the 3D view.

3.) **Show D'art layout**  . Use the D'art tool  to reduce the 3D to a size which only contains the details interesting for an analysis.

4.) **Show Planimetry**  . Use the provided LOIs in the MPRs views to get arbitrary intersections for placing manual measurements (e.g. the opening area of a stenotic valve during diastole).

5.) Use the manual measurement tools for performing user defined measurements on MPRs.

Save Results

- **Save secondary capture** 
  Click this button to store the content of the workspace to the database of the data management platform.
- **Save AVI or BMP** 
  Click this button to export a screen shot (image or clip) to a user selectable target directory.
- **Export results and curves to CSV file** 
  Click this button in order to export measurement values and curve values to a CSV file.

Exit 

Click this button to close the application and return to the Data Management Platform.

Show or hide on-screen help 

Click this button to enable or disable the on-screen help texts in some workflow steps.

6.2 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Automatic Measurement	[Unit]	Description	Formula	maximum allowed absolute deviation
Annulus				
AP Diameter	cm	Distance between point A and P	n/a	5%
AL-PM diameter	cm	Longest distance between two points on the annulus that are derived by intersecting the annulus and a line perpendicular to AP.	n/a	5%
Sphericity index	[ ] calculated	Ratio of AP to AL-PM	AP / AL-PM	5%
Annulus circumference (3D)	cm	Real length of annulus spline	n/a	5%
Annulus area (3D)	cm^2	Size of core area	n/a	5%
Annulus area (2D)	cm^2	Size of area derived by projecting the annulus spline onto the BFP	n/a	5%
Non-planar angle	°	Angle between A, the NPA point and P	n/a	5%
Annulus height	cm	Distance between lowest and highest point on the annulus spline	n/a	5%
Leaflets				
Tenting volume	cm^3	Volume enclosed by RBF-plane (Radial Base Function) and leaflets	n/a	5%
Tenting height	mm	Distance between AP and a point of the closure line that is derived by intersecting a plane through AP perpendicular to BFP with the closure line.	n/a	5%
Tenting area	cm^2	Area lying between AP and the leaflet contours in AP direction	n/a	5%
Leaflet topology	-	Graphical illustration by coloring each point of the leaflet surface of the model according to its distance to the BFP	n/a	n/a

Commissural diameter	cm	Distance between two points on the annulus. Both points are derived by intersecting the annulus spline with a plane that goes through both end points of the coaptation and is perpendicular to the BFP.	n/a	5%
Anterior leaflet area	cm²	Area comprised by the closure line and the anterior part of the annulus.	n/a	5%
Posterior leaflet area	cm²	Area comprised by the closure line and the posterior part of the annulus.	n/a	5%
Posterior leaflet angle	°	Angle between AP and the tip of the posterior leaflet	n/a	5%
Anterior leaflet length	cm	Length of anterior leaflet contour in AP direction	n/a	5%
Posterior leaflet length	cm	Length of posterior leaflet contour in AP direction	n/a	5%
Coaptation				
Anterior closure line length (3D)	cm	Length of the spline that borders the anterior leaflet.	n/a	5%
Posterior closure line length (3D)	cm	Length of the spline that borders the posterior leaflet.	n/a	5%
Anterior closure line length (2D)	cm	Length of projection on BFP of the spline that borders the anterior leaflet.	n/a	5%
Posterior closure line length (2D)	cm	Length of projection on BFP of the spline that borders the posterior leaflet.	n/a	5%
Misc				
Angle AAo-A	°	Angle between the mitral and aortic valve.	n/a	5%
Dynamic				
Annular displacement (max)	mm	Longitudinal movement of annular centroid		5%
Annular displacement velocity (max)	mm/s	1st derivative of annular displacement		5%
Tenting volume fraction	%		(Vmax-Vmin)/Vmax	5%

Annular area fraction (2D)	%		(Amax-Amin)/Amax	5%

Manually performed measurement	[Unit]	Description	Formula	maximum allowed absolute deviation
Manual measurements				
Distance	cm	Measures a distance between two defined points within a MPR. Points can be repositioned by drag and drop.		5%
Area and circumference	cm^2 and cm	Calculates an area and circumference defined by a spline within a MPR (or 3D view). Points can be repositioned by drag and drop. Add a point to the spline with a left-click on the line between two points.		5%
Curve	cm	Calculates an area surrounded by a closed curve consisting of a certain amount of points within a MPR (or 3D view).		5%
Angle	°	Calculates an angle between two lines (4 points) defined within a MPR. Lines can be repositioned by drag and drop.		5%

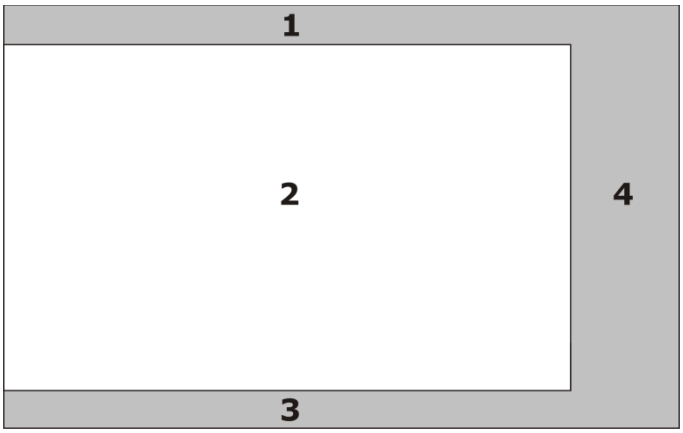
7 Echo-Com© 5.0

7.1 Quick Guide

This chapter introduces the GUI structure of the application and presents an exemplary workflow.

7.1.1 Main Interface Elements

Echo-Com is started from a Data Management Platform.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Toolspace**	offers special functions for performing Wall Motion Scoring.

To get instant help on working with the software first open the **About** box  and then click on the **Help** button to open the manual of the application.

 You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from

www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

7.1.2 User Workflow

CAP Start

1.) Start the platform software (e.g. Image-Arena)
2.) Select a stress echo study

Selection

Aim: Selection of clips for review

1.) **Open the Selection toolspace** to choose the best acquired view.
2.) **Select the clip** by double clicking on it. The software switches automatically to the next view.
3.) **Select more than one clip per view** by using a single click.

Review

Aim: Review and comparison of special stages/views

1.) **Open the Review toolspace**.
2.) **Select Sort by Stage** to display all available views of one stage.
3.) **Select Sort by View** to display one view in all available stages.
4.) **Select Compare** and checkmark special stages and/or views for comparison. It is possible to use up to 4 stages and 3 views for comparison. The layout is automatically adjusted.
5.) **Shuffle** is a predefined sort by view selection with a 2x2 layout. **This mode is only available for two stage protocols.**

Wall Motion Scoring

Aim: Performing a Wall Motion Scoring

1.) **Select the Sector model** ASE 16 or ASE 17.
2.) **Select the Points Scoring Scheme** (4 up to 7 Points).
3.) **Activate a Conventional Numeric Assignment** with a click on it. Click within a wall segment of a sector model to score it.

Display control

Auto-Layout

Use the Toggle auto layout  function to get always the best screen tiling for your selection.

Disable the Toggle auto layout function and click on the Select layout button to choose manually a screen tiling.

Dog-Ear

The dog-ear  icon within a tile of the review state signalizes that there was more than one clip selected for this view. With up  and down  you can temporarily page through all selected clips of the view.

Navigation

Use the hot regions Zoom  and Pan  for navigation with in a tile.

Saving results

- **Save AVI or BMP** 
  Click this button to export the content of the workspace to a user selectable target directory.
- **Save Secondary Capture** 
  Click this button to create and store a Secondary Capture of the content of the workspace (still image or video) to the database of the data management platform.

Exiting the application

- **Launch Image-Com** 
  Click this button to return to Image-Com and set Echo-Com to sleep.
- **Exit** 
  Click this button to return to the Data Management Platform and to store automatically wall motion scorings.

8 2D Cardiac Performance Analysis© 1.2

This chapter introduces to the functionalities of this TomTec software and describes main interface elements of it.

8.1 Supported Data Formats

The application reads the following data formats:

- All b/w 2D DICOM multiframe datasets

8.2 Main Interface Elements

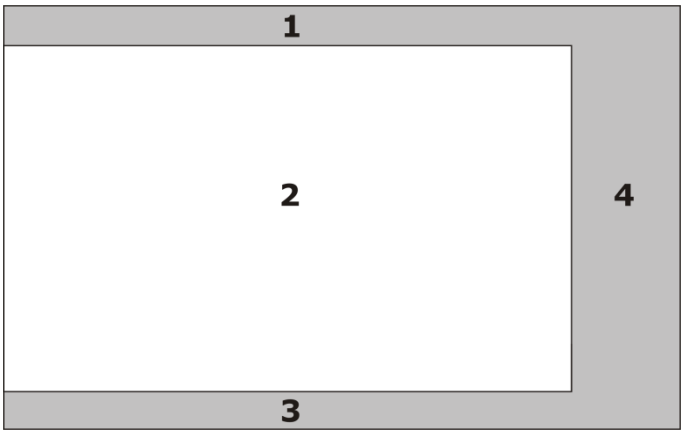
There are different ways to start 2D Cardiac Performance Analysis from:

Data Management Platform (e.g. Image-Arena)

- Position the mouse pointer on an item within the Preview Window of the Patient/Study list of the Data Management Platform (e.g. Image-Arena). Open with a right mouse click the context menu and select Cardiac Performance Analysis. It is also possible to launch Cardiac Performance Analysis with a double click on the same item.

Image-Com

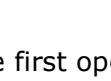
- Position the mouse pointer on an item within the Preview Window of Image-Com. Open with a right mouse click the context menu and select Cardiac Performance Analysis.
- Position the mouse pointer within the active tile at the Workspace of Image-Com. Open with a right mouse click the context menu and select Cardiac Performance Analysis.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Workflow/ Toolspace**	A top down workflow, which guides the user through review and measurement of his examination. At particular workflow steps the Toolspace offers special functions for analysis and measurement.

To get instant help on working with the software first open the **About** box  and then click on the **Help** button to open the manual of the application.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

8.3 Workflow

2D Cardiac Performance Analysis Workflow

All functions needed within one of the main screens can easily be accessed by the buttons of the Toolbar, Workplace and/or Toolspace.

Main displays	Function
Sequence/M-Mode selection	This screen is used for defining the period length of the selected study and for setting R waves and defining the anatomical M-Mode. If the selected dataset contains appendent ECG data, the R-waves are automatically set. 2D Cardiac Performance Analysis needs the heart rate and the length of cardiac cycle for further processing.
Velocity strain analysis	This screen allows to define the view and the spline representing an endocardial (/epicardial contour) at the B-Mode tile. The system calculates graphs and parametric maps to show the tissue movements in different presentations.
3D Display (belongs to Velocity strain analysis)	This screen shows the plot together with its correspondent parametric map in a 3 dimensional construction.

Time-to-Peak Analysis	This screen displays the segmental synchronicity in different presentations (list of evaluated values, valuated segmentation schemes and graphs). The segmentation standard used here is related to six respectively four (for the SAX apex view) particular segments. Each segment has its own color and number. So it is easy to allocate an evaluated value to the correspondent segmentation scheme and to the correspondent graph.

8.4 General Review Tools

Toolbar

Button	Name	Function
	**Export Raw Data**	opens the Save as dialog. Type in a filename, select the destination of your export and click on the Save button. Depending on the actual existing data a data record is exported as txt- and xml-file. Further select the view of your examination and the results of the examination are transferred to the Data Management Platform.  This functionality is intended for research.
	**Export JPG**	exports a screen shot (still frame) consisting of Workspace in JPG format. This screenshot will be exported to a user selectable target directory.
	**Export AVI**	exports a screen shot (movie) consisting of B-mode sequence including contour and vectors in AVI format. This screenshot will be exported to a user selectable target directory.
	**Create Secondary Capture**	creates and stores a Secondary Capture of Workspace and Toolspace contents (still frame). It will be displayed as a thumbnail in the Preview Window at the Database of Data Management Platform.
	**Create Bookmark**	creates and stores a serialization of the dataset together with its Workspace and Toolspace. It will be displayed as a thumbnail in the Bookmark Window at the Database of Data Management Platform. A serialization consists of the original dataset and the results existing at the point of the Bookmark creation. Its thumbnail shows the actual screenshot of the dataset together with its Workspace and Toolspace.

	**Exit**	opens the Save Time-To-Peak Analysis as dialog. Select if the results of the examination should be stored and transferred to the Data Management platform. 2D Cardiac Performance Analysis is closed and the Data Management Platform is displayed. If Cancel is selected, the results won't be transferred and the Data Management Platform is displayed too.

Toolspace		
Button, slider, checkbox, field	Name	Function
	**About**	opens a box with product maintenance information. Further there is a Help button at the bottom of the box. Clicking on it the manual of this application is opened.

Workspace		
Playbar Tools The stepping through a sequence is construed as closed circle. Reaching one of the limiters continues the stepping at the other limiter in the same direction.		
	**Play Phase Loop**	starts and stops the animation of a displayed phase sequence.
	**Previous Phase**	shows the previous phase.
	**Next Phase**	shows the succeeding phase.

To move sliders:

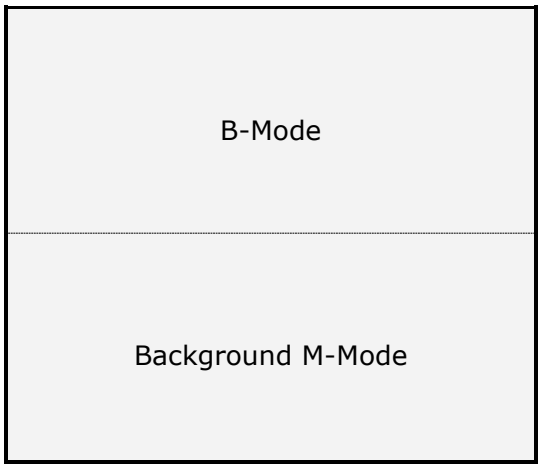
- Grab slider by drag and drop and move it to the desired position.
- Click as often as needed on that side of the slider within its range until it reaches the desired position.

8.5 Sequence/M-Mode selection

After 2D Cardiac Performance Analysis has been started, the Sequence/M-Mode selection screen is opened.

This screen is used for defining the period length of the selected study and for setting R waves and defining the anatomical M-Mode. If the selected dataset contains appendent ECG data, the R-waves are automatically set.

2D Cardiac Performance Analysis needs the heart rate and the length of cardiac cycle for further processing.



Tiles at the step: Sequence/M-Mode selection

Toolspace		
Button, slider, checkbox, field	Name	Function
	Next →	opens the Velocity strain analysis screen.

Display Options		
	Gamma	applies a combination of brightness and contrast to the dataset display. It is used to optimize the representation of the dataset.
	**Restore Gamma Setting**	resets the actual position of the gamma slider to its default position.
	Reverse	inverts the display of the M-Mode Window.

Options		
	Selected Period corresponds to:___ Beats	If the display of the heart rate at the Workspace shows a constant heart rate, the heart rate can manually be typed in here.
	Reset	displays the dataset as originally displayed after it was just opened.

Workspace		
	___ Bpm	displays the heart rate depending on the R wave position. If the study provides ecg data which are displayed at the M-Mode tile, the system automatically determines cardiac cycles by drawing R-wave bars within this tile. Values displayed here cannot be changed.

Mouse functions applicable to the tile containing

Button	Function
B-Mode	
Defining a poly line The poly line defined at the B-Mode tile displays the chronological sequence of movement of points located within the poly line.	
Left, right mouse button	Click once with the left mouse button to define the starting point of the poly line. Continue placing succeeding points the same way. Finish the placement of poly line points by placing the end point with a right mouse click.
Shift a single point of the poly line	
Left mouse button	Select a single point of the poly line to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.
Delete a single point of the poly line	
Right mouse button	Click on a single point of the poly line to remove it.
Background M-Mode	
Period Selector bar It is the header of the M-Mode tile. An ECG signal is displayed there, if the selected dataset contains any. There are two limiters to redefine the positions of the first frame and the last frame of the displayed sequence for processing.	
Left mouse button	Select the limiter to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.
Setting R-wave(s)	
Left mouse button	Click within the M-Mode tile to place an R-wave bar. The second click places another bar. The range between the two bars displayed as a green curve at the top of the M-Mode tile represents a cardiac cycle. It is possible to define more than one cardiac cycle. Clicking on an already existing bar removes it.

8.5.1 Work steps

The following description shows the work steps for the Sequence/M-Mode selection:

1.) Adjust the dataset representation. Use the Gamma settings at the Display Options to display the dataset with the specific details needed for your analysis.
2.) Define a poly line. Define with two or more points a poly line within the B-Mode tile and the background M-Mode image will be calculated.
3.) Define positions of R-waves. If the study provides ECG data, the system automatically determines cardiac cycles, heart rate and positions of R-waves. Having a study without ECG data the user has manually to define the locations of R-waves by himself.
4.) Select the first and the last frame of the sequence. Use the limiters at the Period Selector bar to isolate the interesting period of the sequence for further processing.

8.6 Velocity strain analysis

After performing the settings at the Sequence/M-Mode selection screen, click on the Next→ button to open the Velocity strain analysis screen.

This screen allows to define a spline representing an endocardial (/epicardial contour) at the B-Mode tile. The system calculates graphs and parametric maps to show the tissue movements in different presentations.

<table>
<tr><td rowspan="2">B-Mode</td><td>Plot</td></tr>
<tr><td>Parametric map</td></tr>
<tr><td rowspan="2">Volume/
area
plot</td><td>Plot</td></tr>
<tr><td>Parametric map</td></tr>
</table>

Tiles at the step: Velocity strain analysis

Toolspace

Radio button, slider, check-box, button	Name	Function

Classification of the dataset determines the kind of heart projection the dataset shows: Long Axis views contain open contours and Short Axis Views contain closed contours.

Time-to-Peak Analysis is only for Long Axis and Short Axis views available.

	**Four Chamber View**	Long Axis	apical 4 Chamber projection (open contour)
	**Long Axis View**	Long Axis	apical 3 Chamber or long axis projection
	**Two Chamber View**	Long Axis	apical 2 Chamber projection
	**Short axis Mitral valve plane**	Short Axis	short axis projection at the level of the Mitral Valve
	**Short axis papillary muscle plane**	Short Axis	short axis projection at the level of the Papillary Muscles
	**Short axis apex**	Short Axis	short axis projection at the level of the Apex
	**Free Trace**	arbitrary curve of the endocardium. It is has an open contour and is not available for the Time to peak Analysis.	
	**Set the position between anterior and anteroseptal segment**	opens an additional window. Keep the left mouse button pressed in the image, a line from the center to the outer green border appears and has to be positioned on the border between the anteroseptal and septal segment (for SAX AP between the anterior and septal segment). On the Time to Peak page the segmental model is rotated corresponding to the position done before.	
	16 Seg./ 17 Seg.	defines the correspondent segment model.	
	Endo + Epi	used, if the processing of both borders are required. Perform the endocardial tracing like described afterwards and a double border (Endo- and epicardial border) is automatically drawn.	
	Gamma	For information about these functions please refer to the chapter 8.5 Sequence/M-Mode selection.	
	**Restore Gamma Setting**		

	**Time-to-Peak Analysis**	opens the Time-to-Peak Analysis screen.
	**Start Analysis**	starts the Velocity strain analysis.
	**New Trace**	removes an existing contour and the user can perform another contour tracing. Previous tracings remain on the system. They are displayed under the header History and can be recalled if required.
	**Edit Trace**	Keep the left mouse button pressed over the support point of an existing contour, which has to be shifted. Move the mouse to shift this support point to another location.
	**Sequence/ M-Mode selection**	opens the Sequence/M-Mode selection screen.

	**Decrease vector size**	decreases the length of the vectors displayed at the B-Mode tile.
	**Reset vector size**	resets the length of the vectors displayed at the B-Mode tile to their default length.
	**Increase vector size**	increases the length of the vectors displayed at the B-Mode tile.
	**Toggle contour/vector/ orbit line/ B-Mode**	toggles the B-Mode display between the four states: • with contour • with contour and vectors • orbit line (shows movement trace of the spline support points) • without any overlays
	**Reset graphs display**	shows the plots displays as originally shown after the Velocity strain analysis has just been finished.
	**Zoom in/out**	toggles the B-Mode tile display between two states: • display in upper left corner • full screen display
	**Toggle Filtered/Unfiltered Plots**	toggles the plots of graphs and parametric maps between two states: • plots and maps are displayed without any filter applied to them (their courses are shown as they are) • plots and maps are displayed with a filter applied to them (their courses are smoothed and three tildes are added to their label)

History

The list shown beneath displays the name of each History file performed within this dataset. History files contain actual settings like: sequence length, M-Mode settings, contour, contour/view type, reference frame, heart rate and brightness/contrast/gamma values.

Button	Name	Function
	History file no.	displays the graphs evaluated for the contour performed for this History file.
	**Delete selected contour**	removes only the selected History file from the History file list.

Workspace		
Radio button, button	Name	Function
	Velocity, Displacement, Strain, Strain Rate	select the term, its plots and correspondent parametric maps should be displayed.
	**3D Display**	opens the 3D Display screen and shows the plot together with its correspondent parametric map in a 3 dimensional construction.
	**contour frame**	marks the frame which contains the endocardial contour determined at the Velocity strain analysis screen.

Mouse functions applicable to the tile containing	
Button	Function
B-Mode	
	Click with the left mouse button on +/- to increase/decrease the myocardial thickness (= distance between the endocardial and epicardial border).

Defining a contour	
Left, right mouse button	Click once with the left mouse button to define the starting point of the contour. Continue placing succeeding points the same way. Finish the placement of contour points by placing the end point with a right mouse click.

Shift a single contour point	
Left mouse button	Select a single contour point to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.

Delete a single contour point	
Right mouse button	Click on a single contour point to remove it.

Defining Pinpoints lying within the contour	
Left mouse button	Define with a click a Pinpoint within the contour. The movement of its position is displayed as a graph within the plot and as a line within the correspondent parametric map. The B-Mode has to be frozen before defining Pinpoints. All drawing items mentioned before have the same color.

Plots	
Plots display parameters of endocardial tissue movement vs. time.	
Placing mouse cursor over a graph	displays the component value and time of the place within the graph the cursor points to.

Measuring time	
There are two red bars within a plot. They can be used to measure time spans.	
Left mouse button	Keep the left mouse button pressed over a bar, which position within a graph has to be defined. Move the mouse to an interesting place and release the button to fix the bar there. Define the place for the other bar as described before. The value of the time span enclosed between the bars is displayed over the upper right edge of the plot.

Right mouse button context menu

Name	Function
Save Data to File	opens the Save dialog. Type in a filename, select the destination and click on the Save button. The graph(s) data are stored as a .MAT or .TXT-file.
Copy Data to Clipboard	copies the data of the graph(s) to the clipboard.

Copy Graph to Clipboard	copies a screenshot of the graph(s) to the clipboard.

Parametric maps

The range limits of the time are displayed at the plot(s). The blue and the red color represent two opposed movement directions of tissues. For the particular movements count following determinations:

longitudinal:	Red	directed to Apex
radial:	Red	directed to cavity center
circumferential:	Red	counterclockwise

The blue color always points to the opposed direction of the red color.

Left mouse button	Define with a click the position of a Pinpoint graph within the parametric map. The position of the Pinpoint is shown within the contour at the B-Mode tile and its movement is displayed as a graph within the plot. All drawing items mentioned before have the same color.

Delete a Pinpoint graph within a parametric map

Left mouse button	Click on a single Pinpoint graph to remove it.

Right mouse button context menu

Name	Function
Reset Pinpoints	removes all Pinpoints actually set at the B-Mode tile, graph and parametric map.
Copy	copies a screenshot of the parametric map to the clipboard.

8.6.1 Work steps

The following description shows the work steps for the Velocity strain analysis:

1.) Classify the dataset. Select the kind of heart projection (4Ch, 3Ch, 2Ch, SAX MV, SAX PM, SAX AP, Free Curve) and the options Endo + Epi for the Velocity strain analysis.
2.) Adjust the dataset representation. Use the Gamma settings to display the dataset with the specific details needed for your analysis. Select the frame desired for the endocardial contour tracing by using the Playbar Tools.
3.) Set the endocardial contour for a:

- Long Axis type: Place the first point of the contour spline with a left mouse click on the left side of the mitral annulus. Trace the contour (green) clockwise by including the position of the apex too. Define the position of the last spline point on the right side of the mitral valve with a right mouse click. The spline remains open.

- Short Axis type: Place the first point of the contour spline with a left mouse click on the border from the endocardium to the cavity covered by this part of endocardium. Trace the contour (green) clockwise. Define the position of the last spline point with a right mouse click. The system uses a closed spline for Short Axis tracing.
- Free Curve: Place the first point of the contour spline with a left mouse click on the border from the endocardium to the cavity covered by this part of endocardium. Trace the contour (green) clockwise. Define the position of the last spline point with a right mouse click. The spline remains open.

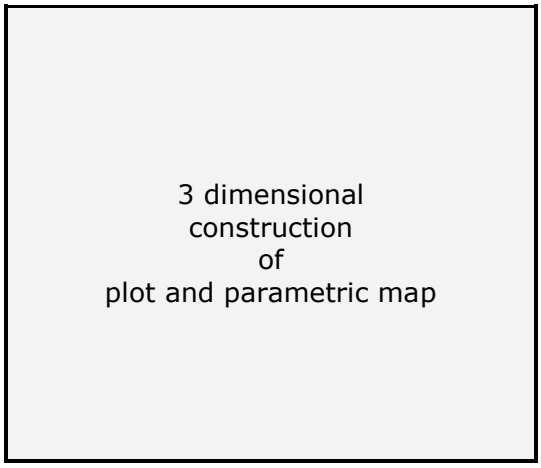
4.) Start Analysis. Click on the Start Analysis button to start the calculations. The results of the analysis are displayed as contour, graphs and parametric maps.

5.) Define a Pinpoint. Define with a click a Pinpoint within the contour or parametric map. The movement of this tissue location will be displayed in different representations (B-Mode tile, graph, parametric map).

8.6.2 3D Display

Click on the 3D Display button to open the 3D Display screen.

This screen shows the plot together with its correspondent parametric map in a 3 dimensional construction.



3D Display screen

Toolspace

Button, slider	Name	Function
	Back →	opens the Velocity strain analysis screen.
	Zoom	zooms the image in and out.
	Reset	displays the 3D construction as originally displayed after it was just opened.

Mouse functions applicable at 3D Display screen	
Left mouse button inside the diagnostic area	Keep the left mouse button pressed and move the mouse to rotate the 3D construction around its virtual center of gravity.

Right mouse button context menu

Name	Function
Reset	displays the 3D construction as originally displayed after it was just opened.
Projection Mode	displays the 3D construction in a Orthogonal or Perspective view.
View Points	directs the Bottom or the Top of the 3D construction towards the user.
Lights	displays the 3D construction with/without 3 dimensional illumination.

8.7 Time-to-Peak Analysis

After performing the Velocity strain analysis, click on the Time-to-Peak Analysis button to open the Time-to-Peak Analysis screen.

This screen displays the segmental synchronicity in different presentations (list of evaluated values, valuated segmentation schemes and graphs). The segmentation standard used here is related to six particular segments. Each segment has its own color and number. So it is easy to allocate an evaluated value to the correspondent segmentation scheme and to the correspondent graph.

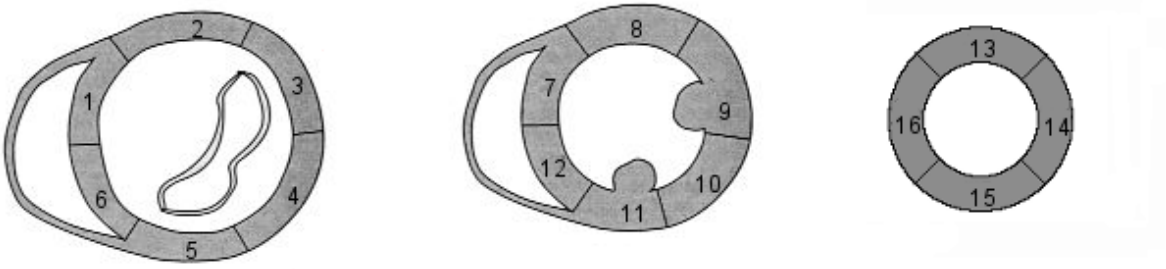
<table>
<tr><td>List of values</td><td rowspan="2">Segmen-
tation
schemes</td><td rowspan="2">Plot</td></tr>
<tr><td rowspan="2">B-Mode</td></tr>
<tr><td>List of values</td><td rowspan="2">Segmen-
tation
schemes</td><td rowspan="2">Plot</td></tr>
</table>

Tiles at the step: Time-to-Peak Analysis

An automatic Time to Peak Analysis is available. The Analysis contains 4 segment model (2 for time to peak and 2 for phase), two graphs, the numeric results and the B-Mode image.

Depending on the view selection (Apical or SAX views) the system automatically displays the segmentation of this view and calculates the Time to Peak and Phase for every segment following the ASE 16 segment model.

a. four chamber view b. two chamber view c. long axis view



d. basal sax view e. mid sax view f. apical sax view

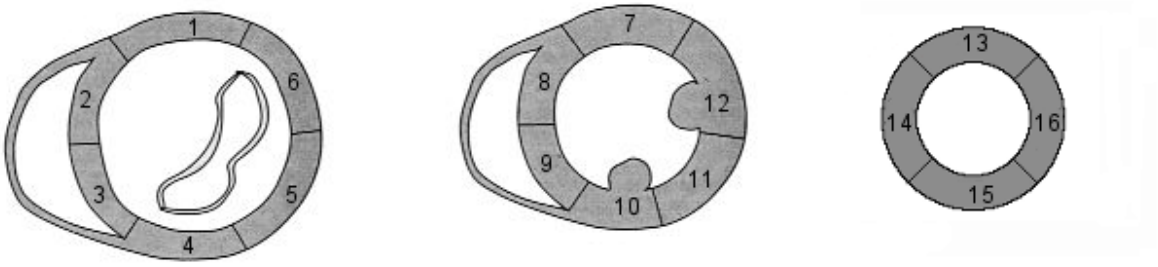
Basal Segments
1= Basal Anteroseptal
2= Basal Anterior
3= Basal Lateral
4= Basal Posterior
5= Basal Inferior
6= Basal Septal

Mid Segments
7= Mid Anteroseptal
8= Mid Anterior
9= Mid Lateral
10= Mid Posterior
11= Mid Inferior
12= Mid Septal

Apical Segments
13= Apical Anterior
14= Apical Lateral
15= Apical Inferior
16= Apical Septal

ASE 16 standard

a. four chamber view b. two chamber view c. long axis view



d. basal sax view e. mid sax view f. apical sax view

Basal Segments	Mid Segments	Apical Segments
1= Basal Anterior	7= Mid Anterior	13= Apical Anterior
2= Basal Anteroseptal	8= Mid Anteroseptal	14= Apical Septal
3= Basal Septal	9= Mid Septal	15= Apical Inferior
4= Basal Inferior	10= Mid Inferior	16= ApicalLateral
5= Basal Posterior	11= Mid Posterior	17= Apex
6= Basal Lateral	12= Mid Lateral	

ASE 17 standard

The time to peak and the phase are displayed colour coded in the segmental display on the left hand side. In the graph the temporal curves of every segment and the average (black curve) is displayed.

If the cursor is moved above the segmental model the corresponding segment number and name is displayed and the corresponding numeric values are highlighted.

According to the positioning of the anteroseptal - septal segment border the SAX segment model is rotated.

Please compare position of segments with arrow in B-Mode.

Toolspace		
Button, checkbox	Name	Function
	Back →	opens the Velocity strain analysis screen.
	**Toggle Filtered/Unfiltered Plots**	For information about this function please refer to chapter 8.6 Velocity strain analysis.
	Reverse Peak	inverts the peak displayed within the R-R interval window (red framed window containing local peaks of the set of curves) from maximum to minimum or inversely. A separate selection for the Radial and Longitudinal/Rotational display is offered. The default is the standard for the left ventricle.
	R-R	shifts the R-R interval window to the next R-R interval.
	**Upside-Down Parametric**	Adapts the segment models to horizontally mirrored data display (e.g. pediatrics)
	History file no.	For information about this function please refer to chapter 8.6 Velocity strain analysis.

Workspace		
Radio button	Name	Function
	Velocity, Displacement, Strain, Strain Rate	For information about this function please refer to chapter 8.6 Velocity strain analysis.

Mouse functions applicable to the tile containing	
Button	Function

List of values

These lists display evaluated Peak and Time to Peak values for each segment, the average value and the value for the Maximum Wall Delay.

B-Mode	
Placing mouse cursor over the B-Mode tile	For information about this function please refer to chapter 8.6 Velocity strain analysis.

Segmentation schemes

They belong to the view of the B-Mode tile and display this view as segmentation schemes. There are two different segmentation schemes:

Time To Peak segmentation. It displays time values for each segment of a Time To Peak scheme. Each of these time values represents the particular time elapsed between the R wave and the peak value of a graph displayed at the plots. The coloring of the particular segments and their values depends on the setting of the R-R interval window displayed within the plots.

Phase segmentation. It displays the phase, which is a more robust synchronicity measure independent of the selected time interval.

Phase is defined here as the phase of the first fundamental Fourier harmonic: the phase of the fundamental harmonic is the dominant information about delays between different time profiles, here the phase of the curve relative to each segment is reported with respect to the phase of the average curve made by averaging all segments' curves. It is expressed in time delay and in percentage of the heartbeat. The color-map shows that a delay of half a heartbeat cannot be distinguished from an anticipation of the following heartbeat.

If the cursor is moved above the segmental model the corresponding segment number and name is displayed and the corresponding numeric values are highlighted.

According to the positioning of the anteroseptal - septal segment border the SAX segment model is rotated.

Deselect/Select a segment	By a left mouse click on a segment, the segment, the correlating curve and numeric values disappear. By clicking again on the segment the segment, the correlating curve and numeric values appear again.
Display all segments	Left mouse click in the center of the segmental model displays all segments (incl. curves and numeric values).
Average	Average of all curves appears as solid line, average of currently selected segments appears as dotted line.

Plots	
Plots display parameters of endocardial tissue movement vs. time.	
Placing mouse cursor over a graph	For information about this function please refer to chapter 8.6 Velocity strain analysis.

Right mouse button context menu

Name	Function
Save Data to File	For information about these functions please refer to chapter 8.6 Velocity strain analysis.
Copy Data to Clipboard	
Copy Graph to Clipboard	

R-R interval window

This window placed within the plots encloses a range around the peaks of the graphs displayed at the plots. It is red framed and its borders can manually be set by the user. The value of the time span enclosed between the bars is displayed over the upper right edge of the plot. If the Time-to-Peak screen is opened the first time the system automatically places the R-R interval window in the plots.

Placing mouse cursor over one border of the R-R interval window	Keep the left mouse button pressed over the border, which has to be shifted. Move the mouse to shift this border to another location.  The color bar is influenced by changing the distance between the two borders.

8.8 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Measurement	[Unit]	Formula	maximum allowed absolute deviation
Tracking			For frame rate > 16 f/s and resolution > 100x100pixel: Maximum error < 20%
Phase			Phase data compared to Phase results: With no noise: error <0,1% With 10% of noise: error <10% With 25% of noise: error <25%
Global LV mass	g/cm³	LVMassES = 1.05*(VolES_epi-VolES)	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.
Global fractional area change	%	FAC = 100*(1-min(Area)/max(Area))	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.
Ejection fraction	%	EF = 100*(1-min(Vol)/max(Vol))	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.

Left ventricular mass end-diastolic	g	LVMassED = 1.05*(VolED_epi-VolED)	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.

9 2D Cardiac Performance Analysis MR© 1.0

This chapter introduces to the functionalities of this TomTec software and describes main interface elements of it.

9.1 Supported Data Formats

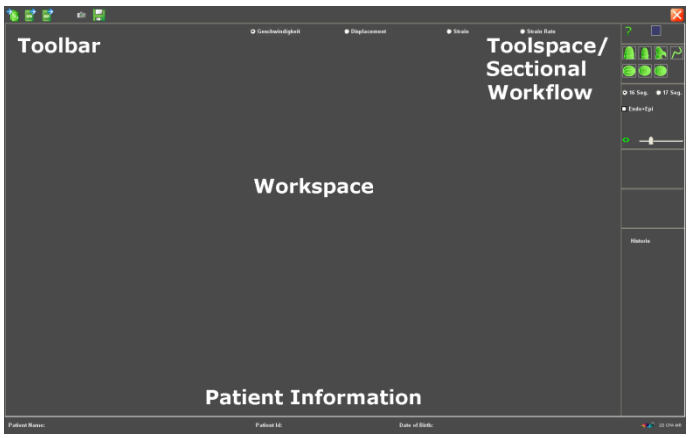
The Software supports all DICOM® MRI data.

9.2 Main Interface Elements

There are different ways to start 2D Cardiac Performance Analysis MR from:

Data Management Platform (e.g. Image-Arena)

- Position the mouse pointer on an item within the Preview Window of the Patient/Study list of the Data Management Platform (e.g. Image-Arena). Open with a right mouse click the context menu and select 2D CPA MR.



Interface elements of 2D Cardiac Performance Analysis MR

Interface element	Description
Toolbar	provides easy access to often used functions on the respective screen.
Toolspace/ Sectional workflow	offers special functions for analysis and measurement; partially build up as a workflow to increase the efficiency of various analysis- and measurement steps.
Workspace	displays the contents of the respective screen. Further it offers functions for replay controlling of the displayed clip and for different representations of tissue parameters (Velocity, Displacement, Strain and Strain Rate) in MR images.

Patient information	displays the most important Patient information.

To get instant help on working with the software double-click on its manual icon on the desktop or click on the Help button in the About box.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

9.3 Workflow

2D Cardiac Performance Analysis MR Workflow

All functions needed within one of the main screens can easily be accessed by the buttons of the Toolbar, Workplace and/or Toolspace.

Main displays	Function
Pre analysis	This screen offers a dialog with a selection of view sequences. This step is only required for MRI data containing more than one heart cycle.
Sequence/M-Mode selection	This screen is used for defining the period length of the selected study and for setting R waves and defining the anatomical M-Mode. If the selected dataset contains appendent ECG data, the R-waves are automatically set. 2D Cardiac Performance Analysis MR needs the heart rate and the length of cardiac cycle for further processing.
Velocity strain analysis	This screen allows to define the spline representing an endocardial (/epicardial contour) at the MR image tile. The system calculates graphs and parametric maps to show the tissue movements in different presentations.
3D Display (belongs to Velocity strain analysis)	This screen shows the plot together with its correspondent parametric map in a 3 dimensional construction.

Time-to-Peak Analysis	This screen displays the segmental synchronicity in different presentations (list of evaluated values, valuated segmentation schemes and graphs). The segmentation standard used here is related to 6/7 respectively four (for the SAX apex view) particular segments. Each segment has its own color and number. So it is easy to allocate an evaluated value to the correspondent segmentation scheme and to the correspondent graph.

9.4 General Review Tools

There are two ways to move sliders:

- Grab slider by drag and drop and move it to the desired position.
- Or click as often as needed on that side of the slider in the slider range until the slider reaches the desired position.

Toolbar

Button	Name	Function
	**Export Raw Data**	opens the Save as dialog. Type in a filename, select the destination of your export and click on the Save button. Depending on the currently selected screen a data record is exported as txt-file and XML-file.  This functionality is intended for research.
	**Export JPG**	exports a screen shot (still frame) consisting of Workspace in JPG format. This screenshot will be exported to a user selectable target directory.
	**Export AVI**	exports a screen shot (movie) consisting of B-mode sequence including contour and vectors in AVI format. This screenshot will be exported to a user selectable target directory.
	**Create Secondary Capture**	creates and stores a Secondary Capture of Workspace and Toolspace contents (still frame). It will be displayed as a thumbnail in the Preview Window at the Database of Data Management Platform.

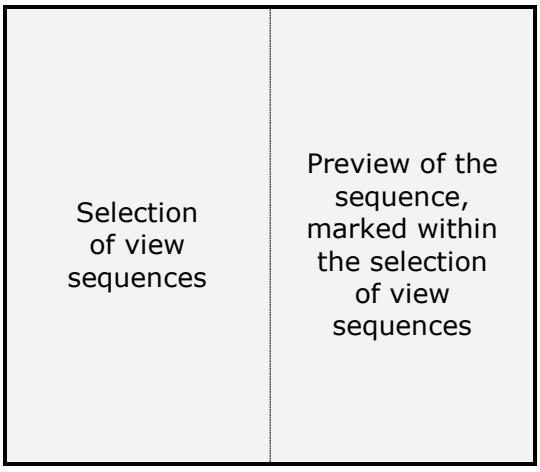
	**Create Bookmark**	creates and stores a serialization of the dataset together with its Workspace and Toolspace. It will be displayed as a thumbnail in the Bookmark Window at the Database of Data Management Platform. A serialization consists of the original dataset and the results existing at the point of the Bookmark creation. Its thumbnail shows the actual screenshot of the dataset together with its Workspace and Toolspace.
	**Exit 2D Cardiac Performance Analysis MR**	opens the Save Time-To-Peak Analysis as dialog. Select if the results of the examination should be stored and transferred to the Data Management platform. 2D Cardiac Performance Analysis MR is closed and the Data Management Platform is displayed. If Cancel is selected, the results won't be transferred and the Data Management Platform is displayed too.

Toolspace		
Button, slider, checkbox, field	Name	Function
	**About 2D-CPA-MR**	opens a box with product maintenance information. Further there is a Help button at the bottom of the box. Clicking on it the manual of this application is opened.

Workspace		
Playbar Tools The stepping through a sequence is construed as closed circle. Reaching one of the limiters continues the stepping at the other limiter in the same direction.		
	**Play Phase Loop**	starts and stops the animation of a displayed phase sequence.
	**Previous Phase**	shows the previous phase.
	**Next Phase**	shows the succeeding phase.

9.5 Pre analysis

After 2D Cardiac Performance Analysis MR has been started, the Pre analysis screen is opened. It consists of a dialog with a selection of view sequences.



Tiles at the step: Pre analysis

Toolspace

Button	Name	Function
	**Pictures mir-roring**	inverts the display of the MR image.

9.5.1 Work steps

The following description shows the work steps for the Pre analysis:

1.) Select a view sequence. Double click on the view sequence which should be analyzed.
2.) Check view direction. Use the Pictures mirroring button to invert the display of the MR image, if required.
3.) Go on with analysis procedure.

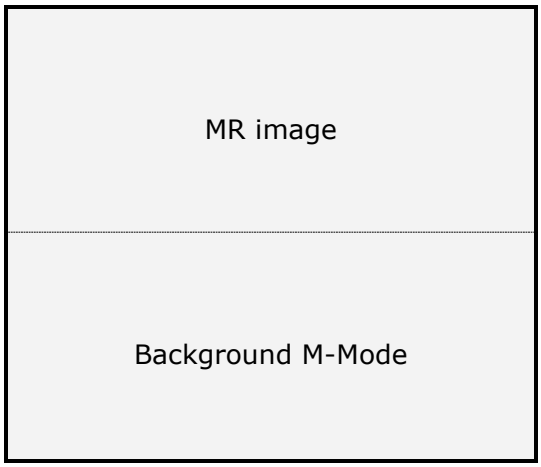
9.6 Sequence/M-Mode selection

This is only an optional step and not necessary for acquisitions where only one heart cycle is recorded!

After 2D Cardiac Performance Analysis MR has been started or a required Pre analysis has been performed before, the Sequence/M-Mode selection screen can be opened by clicking the Sequence/M-Mode selection button.

This screen is used for defining the period length of the selected study and for setting R waves and defining the anatomical M-Mode. If the selected dataset contains appendent ECG data, the R-waves are automatically set.

2D Cardiac Performance Analysis MR needs the heart rate and the length of cardiac cycle for further processing.



Tiles at the step: Sequence/M-Mode selection

Toolspace

Button	Name	Function
	**Slices**	opens the view selection dialog. Double click on the view sequence which should be analyzed.
	**Sequence/M-Mode selection**	opens the Sequence/M-Mode selection screen.

Toolspace of the M-Mode selection screen

Button, slider, checkbox, field	Name	Function
	Next →	opens the Main screen.

Display Options

	Gamma	applies a combination of brightness and contrast to the dataset display. It is used to optimize the representation of the dataset.
	**Restore Gamma Setting**	resets the actual position of the gamma slider to its default position.
	Reverse	inverts the display of the M-Mode Window.

Options		
	Selected Period corresponds to:___ Beats	If the display of the heart rate at the Workspace shows a constant heart rate, the heart rate can manually be typed in here.
	Reset	displays the dataset as originally displayed after it was just opened.

Workspace		
	___ Bpm	displays the heart rate depending on the R wave position. If the study provides ecg data which are displayed at the M-Mode tile, the system automatically determines cardiac cycles by drawing R-wave bars within this tile. Values displayed here cannot be changed.

Mouse functions applicable to the tile containing

Button	Function
B-Mode	
Defining a poly line The poly line defined at the B-Mode tile displays the chronological sequence of movement of points located within the poly line.	
Left, right mouse button	Click once with the left mouse button to define the starting point of the poly line. Continue placing succeeding points the same way. Finish the placement of poly line points by placing the end point with a right mouse click.
Shift a single point of the poly line	
Left mouse button	Select a single point of the poly line to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.
Delete a single point of the poly line	
Right mouse button	Click on a single point of the poly line to remove it.

Background M-Mode	
Period Selector bar It is the header of the M-Mode tile. An ECG signal is displayed there, if the selected dataset contains any. There are two limiters to redefine the positions of the first frame and the last frame of the displayed sequence for processing.	
Left mouse button	Select the limiter to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.
Setting R-wave(s)	
Left mouse button	Click within the M-Mode tile to place an R-wave bar. The second click places another bar. The range between the two bars displayed as a green curve at the top of the M-Mode tile represents a cardiac cycle. It is possible to define more than one cardiac cycle. Clicking on an already existing bar removes it.

9.6.1 Work steps

The following description shows the work steps for the Sequence/M-Mode selection:

1.) Adjust the dataset representation. Use the Gamma settings at the Display Options to display the dataset with the specific details needed for an analysis.
2.) Define a poly line. Place contour points of a poly line with left clicks within the MRI image and the background M-Mode image will be calculated. A right click ends the contouring. Please draw the poly line always clockwise.

Drawing a poly line counter clockwise will result in a wrong assignment of segments at the Time-to-Peak Analysis screen.

3.) Define positions of R-waves. If the study provides ECG data, the system automatically determines cardiac cycles, heart rate and positions of R-waves. Having a study without ECG data the user has manually to define the locations of R-waves by himself.
4.) Select the first and the last frame of the sequence. Use the limiters at the Period Selector bar to isolate the interesting period of the sequence for further processing.
5.) Click on the Next button to open the Main screen.

9.7 Velocity strain analysis

After performing the settings at the Sequence/M-Mode selection screen, click on the Next→ button to open the Main screen.

This screen allows to define a spline representing an endocardial (/epicardial contour) at the MR image tile. The system calculates graphs and parametric maps to show the tissue movements in different presentations.

MR image	Plot
	Parametric map
Volume/ area plot	Plot
	Parametric map

Tiles at the step: Velocity strain analysis

Toolspace

Button, radio button, checkbox slider	Name	Function
	**Slices**	For information about this function please refer to chapter 9.6 Sequence/M-Mode selection.

Classification of the dataset determines the kind of heart projection the dataset shows: Long Axis views contain open contours and Short Axis Views contain closed contours.

Time-to-Peak Analysis is only for Long Axis and Short Axis views available.

	**Four Chamber View**	Long Axis	apical 4 Chamber projection (open contour)
	**Two Chamber View**	Long Axis	apical 2 Chamber projection
	**Long Axis View**	Long Axis	apical 3 Chamber or long axis projection
	**Free Trace**	arbitrary curve of the endocardium. It is has an open contour and is not available for the Time to peak Analysis.	
	**Short axis Mitral valve plane**	Short Axis	short axis projection at the level of the Mitral Valve

	**Short axis papillary muscle plane**	Short Axis	short axis projection at the level of the Papillary Muscles
	**Short axis apex**	Short Axis	short axis projection at the level of the Apex
	**Set the position between anterior and anteroseptal segment**	opens an additional window. Keep the left mouse button pressed in the image, an arrow from the center to the outer green border appears and has to be positioned on the border between the anteroseptal and septal segment (for SAX AP between the anterior and septal segment). On the Time to Peak page the segmental model is rotated corresponding to the position done before.	

	16 Seg.	defines the correspondent ASE segment model.
	17 Seg.	
	Endo + Epi	used, if the processing of both borders are required. Perform the endocardial tracing like described afterwards and a double border (Endo- and epicardial border) is automatically drawn.
	Gamma	applies a combination of brightness and contrast to the dataset display. It is used to optimize the representation of the dataset.
	**Restore Gamma Setting**	resets the actual position of the gamma slider to its default position.

	**Time-to-Peak Analysis**	opens the Time-to-Peak Analysis screen.
	**Start Analysis**	starts the Velocity strain analysis.
	**New Trace**	removes an existing contour and the user can perform another contour tracing. Previous tracings remain on the system. They are displayed under the header History and can be recalled if required.
	**Edit Trace**	Keep the left mouse button pressed over the support point of an existing contour, which has to be shifted. Move the mouse to shift this support point to another location.
	**Sequence/ M-Mode selection**	For information about this function please refer to chapter 9.6 Sequence/M-Mode selection.

	**Decrease vector size**	decreases the length of the vectors displayed at the MR image tile.
	**Reset vector size**	resets the length of the vectors displayed at the MR image tile to their default length.
	**Increase vector size**	increases the length of the vectors displayed at the MR image tile.
	**Toggle contour/vector/orbit line/B-Mode**	toggles the MR image display between four states: • with contour • with contour and vectors • orbit line (shows movement trace of the spline support points) • with Endo- and Epi-contour. Both contours are connected via auxiliary lines, which especially express the wall motion. This feature is only available, if the Endo + Epi checkbox was marked before. • without any overlays
	**Reset graphs display**	shows the plots displays as originally shown after the Velocity strain analysis has just been finished.
	**Zoom in/out**	toggles the MR image tile display between two states: • display in upper left corner • full screen display
	**Toggle Filtered/Unfiltered Plots**	toggles the plots of graphs and parametric maps between two states: • plots and maps are displayed without any filter applied to them (their courses are shown as they are) • plots and maps are displayed with a filter applied to them (their courses are smoothed and three tildes are added to their label)

History

The list shown beneath displays the name of each History file performed within this dataset. History files contain actual settings like: sequence length, M-Mode settings, contour, contour/view type, reference frame, heart rate and brightness/contrast/gamma values.

Button	Name	Function
	History file no.	displays the graphs evaluated for the contour performed for this History file.

	**Delete selected contour**	removes only the selected History file from the History file list.

Workspace		
Radio button, button	Name	Function
	Velocity, Displacement, Strain, Strain Rate	select a term. Its plots and correspondent parametric maps will be displayed.
	**3D Display**	opens the 3D Display screen and shows the plot together with its correspondent parametric map in a 3 dimensional construction.
	**contour frame**	marks the frame which contains the endocardial contour determined at the Main screen.

Mouse functions applicable to the tile containing	
Button	Function
MR image	
	Click with the left mouse button on +/- to increase/decrease the myocardial thickness (= distance between the endocardial and epicardial border).

Defining a contour	
Left, right mouse button	Click once with the left mouse button to define the starting point of the contour. Continue placing succeeding points the same way. Finish the placement of contour points by placing the end point with a right mouse click.

Shift a single contour point	
Left mouse button	Select a single contour point to be shifted. Keep the left mouse button pressed on it and move the mouse to relocate it.

Defining Pinpoints lying on the contour	
Left mouse button	Define with a click a Pinpoint within the contour. The movement of its contour position is displayed as a graph within the plot and as a line within the correspondent parametric map. The MR image has to be frozen before defining Pinpoints. All drawing items mentioned before have the same color.

Plots	
Plots display parameters of endocardial tissue movement vs. time.	
Placing mouse cursor over a graph	displays the component value and time of the place within the graph, the cursor points to.

Measuring time	
There are two red bars within a plot. They can be used to measure time spans.	
Left mouse button	Keep the left mouse button pressed over a bar, which position within a graph has to be defined. Move the mouse to an interesting place and release the button to fix the bar there. Define the place for the other bar as described before. The value of the time span enclosed between the bars is displayed over the upper right edge of the plot.

Right mouse button context menu

Name	Function
Save Data to File	opens the Save dialog. Type in a filename, select the destination and click on the Save button. The graph(s) data are stored as a.TXT-file.

Parametric maps		
The range limits of the time are displayed at the plot(s). The blue and the red color represent two opposed movement directions of tissues. For the particular movements count following determinations:		
longitudinal:	Red	directed to Apex
radial:	Red	directed to cavity center
circumferential:	Red	counterclockwise
The blue color always points to the opposed direction of the red color.		

Defining Pinpoints lying on the contour by defining a pinpoint line	
Left mouse button	Define with a click the position of a Pinpoint line within the parametric map. The position of the Pinpoint is shown within the contour at the MR image tile and its movement is displayed as a graph within the plot. The MR image has to be frozen before defining Pinpoints. All drawing items mentioned before have the same color.

Right mouse button context menu

Name	Function
Reset Pinpoints	removes all Pinpoints actually set at the MR image tile, graph and parametric map.
Copy	copies a screenshot of the parametric map to the clipboard.

9.7.1 Work steps

The following description shows the work steps for the Velocity strain analysis:

1.) Classify the dataset. Click on the appropriate view button (4Ch, Long Axis, 2Ch, SAX MV, SAX PM, SAX AP, Free Trace) to define the view according to the loaded sequence.
2.) Adjust the dataset representation. Use the Gamma settings to display the dataset with the specific details needed for your analysis. Select the frame desired for the endocardial contour tracing by using the Playbar Tools.
3.) Define two borders (Endo, Epi), optionally. Mark the Endo + Epi checkbox if the processing of both borders is required.
4.) Set the endocardial contour for a:

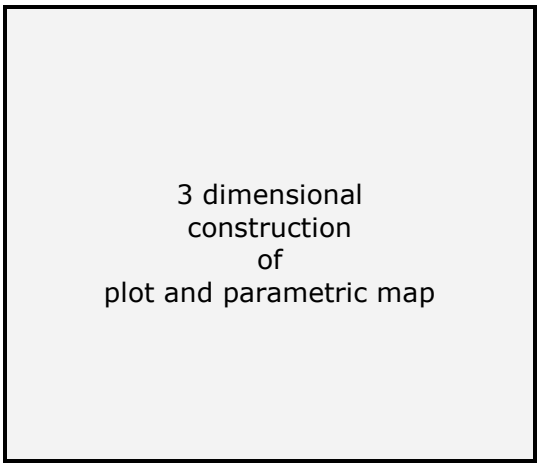
- Long Axis type: Place the first point of the contour spline with a left mouse click on the left side of the mitral annulus. Trace the contour clockwise by including the position of the apex too. Define the position of the last spline point on the right side of the mitral valve with a right mouse click. The spline remains open.
- Short Axis type: Place the first point of the contour spline with a left mouse click on the border from the endocardium to the cavity covered by this part of endocardium. Trace the contour clockwise. Define the position of the last spline point with a right mouse click. The system uses a closed spline for Short Axis tracing.
- Free Trace: Place the first point of the contour spline with a left mouse click on the border from the endocardium to the cavity covered by this part of endocardium. Trace the contour clockwise. Define the position of the last spline point with a right mouse click. The spline remains open.

5.) Start Analysis. Click on the Start Analysis button to start the calculations. The results of the analysis are displayed as contour, graphs and parametric maps.
6.) Define a Pinpoint. Define with a click a Pinpoint within the contour or parametric map. The movement of this tissue location will be displayed in different representations (MR image tile, graph, parametric map).

9.7.2 3D Display

Click on the 3D Display button to open the 3D Display screen.

This screen shows the plot together with its correspondent parametric map in a 3 dimensional construction.



3D Display screen

Toolspace		
Button, slider	Name	Function
	Back →	opens the Velocity strain analysis screen.
	Zoom	zooms the image in and out.
	Reset	displays the 3D construction as originally displayed after it was just opened.

Mouse functions applicable at 3D Display screen	
Left mouse button inside the diagnostic area	Keep the left mouse button pressed and move the mouse to rotate the 3D construction around its virtual center of gravity.

Right mouse button con-text menu	
Name	Function
Reset	displays the 3D construction as originally displayed after it was just opened.
Projection Mode	displays the 3D construction in a Orthogonal or Perspective view.
View Points	directs the Bottom or the Top of the 3D construction towards the user.
Lights	displays the 3D construction with/without 3 dimensional illumination.

9.8 Time-to-Peak Analysis

After performing the Velocity strain analysis, click on the Time-to-Peak Analysis button to open the Time-to-Peak Analysis screen.

This screen displays the segmental synchronicity in different presentations (list of evaluated values, valuated segmentation schemes and graphs). The segmentation standard used here is related to 6/7 particular segments. Each segment has its own color and number. So it is easy to allocate an evaluated value to the correspondent segmentation scheme and to the correspondent graph.

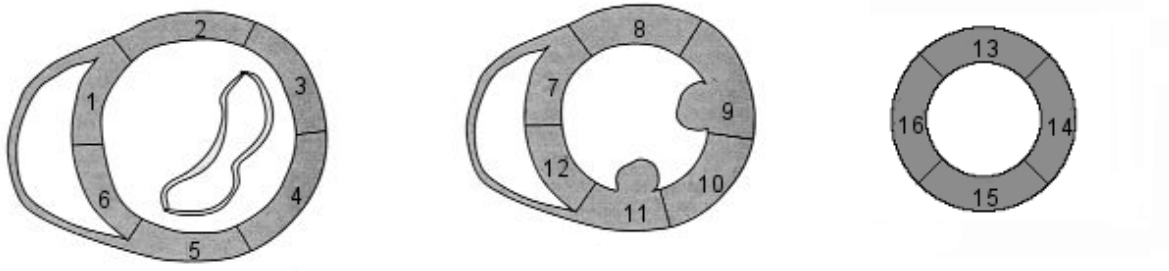
<table>
<tr><td>List of values</td><td rowspan="2">Segmen-
tation
schemes</td><td rowspan="2">Plot</td></tr>
<tr><td rowspan="2">MR image</td></tr>
<tr><td>List of values</td><td rowspan="2">Segmen-
tation
schemes</td><td rowspan="2">Plot</td></tr>
</table>

Tiles at the step: Time-to-Peak Analysis

An automatic Time to Peak Analysis is available. The Analysis contains 4 segment model (2 for time to peak and 2 for phase), two graphs, the numeric results and the MR image.

Depending on the view selection (Apical or SAX views) the system automatically displays the segmentation of this view and calculates the Time to Peak and Phase for every segment following the ASE 16/17 segment model.

a. four chamber view b. two chamber view c. long axis view



d. basal sax view e. mid sax view f. apical sax view

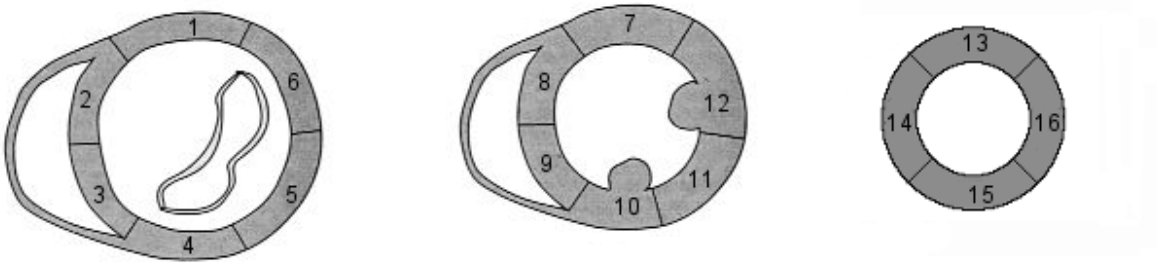
Basal Segments
1= Basal Anteroseptal
2= Basal Anterior
3= Basal Lateral
4= Basal Posterior
5= Basal Inferior
6= Basal Septal

Mid Segments
7= Mid Anteroseptal
8= Mid Anterior
9= Mid Lateral
10= Mid Posterior
11= Mid Inferior
12= Mid Septal

Apical Segments
13= Apical Anterior
14= Apical Lateral
15= Apical Inferior
16= Apical Septal

ASE 16 standard

a. four chamber view b. two chamber view c. long axis view



d. basal sax view e. mid sax view f. apical sax view

Basal Segments	Mid Segments	Apical Segments
1= Basal Anterior	7= Mid Anterior	13= Apical Anterior
2= Basal Anteroseptal	8= Mid Anteroseptal	14= Apical Septal
3= Basal Septal	9= Mid Septal	15= Apical Inferior
4= Basal Inferior	10= Mid Inferior	16= ApicalLateral
5= Basal Posterior	11= Mid Posterior	17= Apex
6= Basal Lateral	12= Mid Lateral	

ASE 17 standard

The time to peak and the phase are displayed color coded in the segmental display on the left hand side. In the graph the temporal curves of every segment and the average (white curve) is displayed.

If the cursor is moved above the segmental model the corresponding segment number and name is displayed and the corresponding numeric values are highlighted.

According to the positioning of the anteroseptal - septal segment border the SAX segment model is rotated.

Please compare position of segments marked with an arrow at the MR image (only for short axis views).
For information about this arrow please refer to the "Set the position between anterior and anteroseptal segment" function at the chapter 9.7 Velocity strain analysis.

Toolspace		
Button, checkbox	Name	Function
	Back →	opens the Velocity strain analysis screen.
	**Toggle Filtered/Unfiltered Plots**	For information about this function please refer to chapter 9.7 Velocity strain analysis.
	R-R	shifts the R-R interval window to the next R-R interval.
	Average	displays the average curve of all temporal curves, which are shown within a plot (Velocity, Displacement, Strain, Strain Rate).
	Reverse Peak	inverts the peak displayed within the R-R interval window (red framed window containing local peaks of the set of curves) from maximum to minimum or inversely. A separate selection for the Radial and Longitudinal/Rotational display is offered. The default is the standard for the left ventricle.
	Segment Model	defines the correspondent ASE segment model.
	History file no.	For information about this function please refer to chapter 9.7 Velocity strain analysis.

Workspace		
Radio button	Name	Function
	Velocity, Displacement, Strain, Strain Rate	For information about this function please refer to chapter 9.7 Velocity strain analysis.

Mouse functions applicable to the tile containing	
Button	Function

List of values

These lists display evaluated Peak and Time to Peak values for each segment, the average value and the value for the Maximum Wall Delay.

Segmentation schemes

They belong to the view of the MR image tile and display this view as segmentation schemes. There are two different segmentation schemes:

Time To Peak segmentation. It displays time values for each segment of a Time To Peak scheme. Each of these time values represents the particular time elapsed between the R wave and the peak value of a graph displayed at the plots. The coloring of the particular segments and their values depends on the setting of the R-R interval window displayed within the plots.

Phase segmentation. It displays the phase, which is a more robust synchronicity measure independent of the selected time interval.

Phase is defined here as the phase of the first fundamental Fourier harmonic: the phase of the fundamental harmonic is the dominant information about delays between different time profiles, here the phase of the curve relative to each segment is reported with respect to the phase of the average curve made by averaging all segments' curves. It is expressed in time delay and in percentage of the heartbeat. The color-map shows that a delay of half a heartbeat cannot be distinguished from an anticipation of the following heartbeat.

If the cursor is moved above the segmental model the corresponding segment number and name is displayed and the corresponding numeric values are highlighted.

According to the positioning of the anteroseptal - septal segment border the SAX segment model is rotated.

Deselect/Select a segment	By a left mouse click on a segment, the segment, the correlating curve and numeric values disappear. By clicking again on the segment the segment, the correlating curve and numeric values appear again.
Display all segments	Left mouse click in the center of the segmental model displays all segments (incl. curves and numeric values).
Average	By selecting or deselecting average the average value and curve is displayed or not.

Right mouse button context menu

Name	
Copy parametric map to the clipboard	Using a "Right mouse button" click you can copy graphics to the clipboard to be used in third party programs.

Plots Plots display parameters of endocardial tissue movement vs. time.	
Placing mouse cursor over a graph	For information about this function please refer to chapter 9.7 Velocity strain analysis.

Right mouse button context menu

Name	Function
Save Data to File	For information about this function please refer to chapter 9.7 Velocity strain analysis.

R-R interval window

This window placed within the plots encloses a range around the peaks of the graphs displayed at the plots. It is red framed and its borders can manually be set by the user. The value of the time span enclosed between the bars is displayed over the upper right edge of the plot. If the Time-to-Peak screen is opened the first time the system automatically places the R-R interval window in the plots.

Placing mouse cursor over one border of the R-R interval window	Keep the left mouse button pressed over the border, which has to be shifted. Move the mouse to shift this border to another location.  The color bar is influenced by changing the distance between the two borders.

9.9 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the tables below:

Measurement	Formula	Acceptance criteria
Tracking		For frame rate > 16 f/s and resolution > 100x100pixel: Average error < 10%; Maximum error < 20%
Phase		Phase data compared to Phase results: With no noise: error <0,1% With 10% of noise: error <10% With 25% of noise: error <25%
Global LV Mass	LVMassES = 1.05*(VolES_epi-VolES) [gr/cm^3]	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.
Global Fractional Area Change	FAC = 100*(1-min(Area)/max(Area))	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.
Ejection Fraction	EF = 100*(1-min(Vol)/max(Vol))	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.
Left Ventricular Mass enddiastolic	LVMassED = 1.05*(VolED_epi-VolED)	Values calculated by the software differ from values calculated manually with the same formula only about maximal 1%.

10 4D Sono-Scan™ 2.0

This chapter introduces to the functionalities of this TomTec software and describes main interface elements of it.

10.1 Supported Data Formats

The software is merely intended for 4D ultrasound data.

Supported data formats:

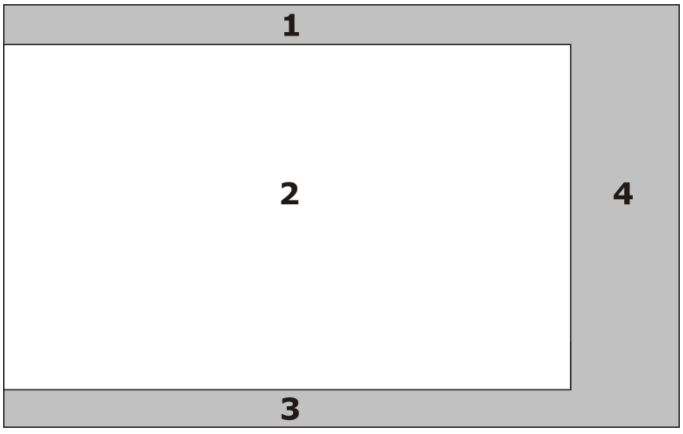
- 3D/4D data Toshiba Xario/Aplio
- 3D/4D data Zonare Z.ONE
- 3D/4D data General Electric Voluson/LOGIQ
- 3D/4D data Philips IU22
- 3D/4D data Alpinion E-Cube
- 3D/4D data Visualsonics Vevo

10.2 Data Compression

No image compression algorithms are used for image visualization.

10.3 Main Interface Elements

This section presents a general overview of the main interface elements.



Interface elements of the application

Interface elements

No.	Name	Description
1	**Toolbar**	provides easy access to the most often used functions on the respective screen.
2	**Workspace**	displays the contents of the respective screen.
3	**Patient information**	displays the most important patient information.
4	**Workflow/ Toolspace**	A top down workflow, which guides the user through review and measurement of his examination. At particular workflow steps the Toolspace offers special functions for analysis and measurement.

You will need Adobe Acrobat Reader to display the software manual. If Adobe Acrobat Reader is not installed on your system, go to the directory /Adobe on your software CD, execute the installation file or download the latest version of Adobe Acrobat Reader from www.adobe.com. This will start the installation of Adobe Acrobat Reader. Follow the instructions on the screen to perform the installation.

10.4 General Review Tools

The 4D Sono-Scan application has different displays. Generally click inside a tile to tag it as the active one. Four colored corners indicate the tile is active. Within each tile there are colored lines visible, which indicate the position of the corresponding views. Depending on the color of the corners at the active tile, the user find correspondent color-coded axes at the other tiles.

A spatial display of the 2D cut planes (MPRs) is only available at the VR. This helps the user to get a good impression of a rendered data volume while navigating through it.

There are two ways to move sliders:

- Grab slider by drag and drop and move it to the desired position.
- Or click as often as needed on that side of the slider in the slider range until the slider reaches the desired position.

10.4.1 Toolbar

It contains often needed functionalities for dataset handling.

Toolbar		
Button	Name	Function
	**Reset**	displays the dataset as originally displayed in the beginning of each workflow step.
	**Save Bookmark**	opens the Save Bookmarks dialog. Type in a filename and click on the Save button. A serialization of the dataset will be created.
	**Save secondary capture**	exports a screen shot (still frame or movie).
Tiling		
	Single View	displays the selected tile in maximum size within the Workspace.
	**Dual View**	displays a horizontal dual tiling within the Workspace. The left tile displays a MPR tile and the right one the VR tile.
	**Quad View**	displays a quad tiling within the Workspace. It consists of 3 MPR tiles and a VR tile. Each MPR is orthogonal to the other ones.
Layout Only one layout can be selected - combinations are not possible. A Region of Interest (further named as ROI) can be defined. Each clicking on a Layout button opens the Layout Settings tab at the Toolspace. For information about the tools provided at the Layout Settings tab please refer to the chapter 10.4.6 Toolspace – Layout Settings tab.		
	**Volume**	displays the classic layout containing one or more MPR view(s) and one or no VR view. Three different tilings (Single-, Dual-, and Quad tiling) are available.
	**Cubic View**	displays the classic layout containing 3 MPR views and a VR view. The normal VR View is exchanged by perpendicular constructions of A-, B- and C-plane. They are: • Box • Niche • Plane Three different tilings are available for each VR view: Single tiling: VR only Dual tiling: A-plane and VR Quad tiling: A-, B-, C-plane and VR

	**Curved-Slice**	displays the classic layout containing 4 MPR views. The three remaining views can be filled with MPRs by drawing splines within the upper left MPR view. There are two different Curved-Slice layouts available: Curved planar reconstruction: The free views can consecutively be filled. Three curved planar reconstructions: All of the free views can be filled at the same time.
	**Multi-Slice**	Multi-Slice is a view where it is possible to review the VR divided in different equidistant slices. The number of slices can be defined by certain presets. Five different tilings (Single-, Dual-, Quad-, 9-, and 16-tiling) are available.
	**Multi-Slice D'art**	Multi-Slice D'art has the same functionality as Multi-Slice. Only a range - determined by the D'art functionality - will be divided into equidistant slices instead of the whole volume. This range can be defined by two mouse clicks.
Playbar tools		
	**Previous frame**	shows the previous phase.
	**Pause**	stops the animation of a displayed phase sequence.
	**Play**	starts the animation of a displayed phase sequence.
	**Next frame**	shows the succeeding phase.
	**About**	opens a box with information about the product for maintenance.
	**Exit**	closes the application and returns to the Data Management Platform.

10.4.2 Workspace

It contains needed functionalities for dataset, MPR and VR handling. They are available as buttons, context menus and mouse actions.

Workspace

Button / Item	Name	Function
Navigation triggered by mouse action 6 Navigation tools are available for navigating MPR/Curved-Slice/VR within the active tile. They are placed at the upper right corner of the Workspace.		
Mouse wheel	**Select navigation tool**	Rotate the mouse wheel to select one of the sequentially highlighted Navigation tools.
		Alternatively the Navigation tools can be selected by clicking on their Icons.
	**Axe-Wise**	Keep the left mouse button pressed and move the mouse to rotate the tile content around its vertical or horizontal axis. While the left mouse button is pressed the rotation can only be performed around one axis. Release the button, keep it pressed again, and move the mouse to the other direction the rotation around the other axis is selected.
	**Orbit**	Keep the left mouse button pressed and move the mouse to rotate the tile content around its vertical/horizontal axis. The rotation around both axes can be performed with one mouse action.
	**Rotate**	Keep the left mouse button pressed and move the mouse to rotate the tile content around the axis perpendicular to the screen.
	**Pan**	Keep the left mouse button pressed and move the mouse to relocate the tile content within its tile.
	**Slice**	Keep the left mouse button pressed and move the mouse to move the selected cut plane in parallel slices backward and forward.
	**Zoom**	Keep the left mouse button pressed and move the mouse to zoom the tile content in and out.
Double click within a tile		toggles between displaying the selected tile as a part of the current tiling and displaying it in Single tiling.
	**View direction**	indicates from which side of the data volume the user has a look at the correspondent cut plane (2D image).

	**Volume Indicator**	The Volume Indicator consists of a red/blue colored pyramid surrounded by a gray three-dimensional (3D) wireframe (MPRs and VR). It represents the spatial position of a MPR or the VR. The scan direction is indicated by two colors. The red side of the Volume Indicator represents the first view and the blue one represents the last view of the acquired dataset. Only at the VR tile the Volume Indicator additionally shows 2D cut planes as color coded wireframes. An active MPR tile has colored edges. The spatial position of this MPR within the VR is represented by a 2D cut plane(displayed as a wireframe). It has the same color like the colored edges of the active MPR. Based on an active tile and the color of its edges, each other tile has a pair of correspondently colored View direction markers along its borders.
	**Frame slider**	marks the currently displayed frame.

10.4.3 Toolspace – Render Settings tab

It contains tools needed to adjust the representation of MPRs, Curved Slices and the VR. Their use depends on the image quality of the loaded dataset and on the details the user wants to see.

Slider, button, pulldown menu, field	Name	Function
	**Render Settings tab**	These tools allow different representations of the dataset.
Threshold/Transparency These tools are only applicable to VR.		
	**Threshold**	separates an object of interest from the background and/or unwanted data (noise). Threshold settings help to define which structures are relevant for the reconstruction and which ones are not. Gray values above the adjusted threshold are taken into account for the reconstruction, and gray values below are ignored.
	**Transparency**	determines the appearance of a rendered volume. A value of 0 creates a solid surface. Increasing this value the transparency of the volume is increased too.

Gradient/Intensity These tools are only applicable to VR.		
	**Gradient**	mixes and adjusts the gradient shading and texture shading algorithms for a maximum image quality and the freedom to tailor images according their application.
	**Intensity**	adjusts the concentration or strength of the texture shading algorithm.
Brightness/Contrast These tools are only applicable to MPRs.		
	**Brightness**	lightens or darkens tissue and colors equally.
	**Contrast**	adjusts the difference between light and dark tissue as well as light and dark colors.
Render mode These tools are only applicable to VR.		
	**Gradient Mode**	applies adjusted and mixed gradient shading and texture shading algorithms for a maximum image quality and the freedom to tailor images according their application to the VR.
	**Max IP mode**	represents the maximum gray values of the tissue found within the VR.
	**X-ray mode**	applies algorithms, which use a semitransparent shading model with the emphasis put on bright structures. The tissue of the VR has similarities to an object melted into a block of semitransparent glass.
	**Cavity**	displays the gray values, found within the VR, inverted.
3D Filter These tools are only applicable to VR.		
	**No Filter**	displays the tissue of the VR with structural details.
	**Moderate**	applies a mild low-pass filter to the tissue of VR to get a good compromise between structural detail and a smooth display. This is the default filter.
	**Medium**	applies a moderate low-pass filter to the tissue of the VR to get a smooth image and removes artifacts and some noise.
	**Heavy**	applies a strong low-pass filter to the tissue of the VR to get a very smooth image.

2D Filter – SRI These tools are only applicable to MPRs.		
	**Abdomen**	This filter preset is designed for a better display of structures in the abdomen like the liver and the spleen.
	**Carotid**	This filter preset is designed to improve the display of the carotid.
	**OB**	This filter preset is designed to improve the display of fetuses.
	**Thyroid**	This filter preset is designed to improve the display of the thyroid.
Thick slice These tools are only applicable to MPRs.		
	**Thick slice small**	applies a moderate noise filter to the MPRs.
	**Thick slice medium**	applies a medium noise filter to the MPRs.
	**Thick slice large**	applies a strong noise filter to the MPRs.
	**Thick slice huge**	applies a very strong noise filter to the MPRs.
Presets		
	Pulldown menu of Presets	displays hard coded or user defined Presets. Hard coded presets are indicated by capital letters and cannot be deleted. User defined presets can be generated by typing an individual preset name into the input field and push the save button on the right side. If the save button is not highlighted the preset cannot be saved since wrong name convention was used. E.g. capital characters are reserved for the hard coded presets. In this case please use small characters for the preset naming. Already saved presets can be selected from the dropdown box. As soon as the image parameters are changed so that they do not match with the last selected preset anymore the preset box will indicate "None".
	**Erase Preset**	removes the Preset selected within the Pulldown menu of Presets. Only user defined Presets can be removed.

	Input field for user defined Preset names	enter the name for the selected render settings configuration.
	**Save Preset**	saves the selected render settings configuration with the name entered in the Input field for user defined Preset names on the left side of this button.
Tissue palette		
	MPR	applies one of the available color schemes to the MPRs.
	3D	applies one of the available color schemes to the VR.

10.4.4 Toolspace - Tools tab

It contains tools needed to animate the displayed dataset. Further unwanted parts inside the VR can be removed.

Button, field, slider, radio button	Name	Function
	**Tools tab**	These tools allow the animation of the dataset and the removing of unwanted parts inside the VR.
Phase		
	**Previous frame**	For Information about these functions please refer to the Playbar tools at the chapter 10.4.1 Toolbar.
	**Pause**	
	**Play**	
	**Next frame**	
	Loop	Phase sequence is played in a continuous loop. Reaching the end the phase sequence starts from the beginning.
	Sweeping	Phase sequence is continuously played from the beginning to the end and back and so on.
	Velocity	changes the speed of the animated sequence.
Animation These tools are only applicable to VR.		

	**Vertical rotation**	starts/stops a rocking motion of the *VR* around its vertical axis.
	**Horizontal rotation**	starts/stops a rocking motion of the *VR* around its horizontal axis.
	**Toggle animation speed**	toggles between fast and slow rocking motion.
	Angle	adjusts the size of the rocking motion-angle. The set angle corresponds with the angle displayed between the both final positions of the rocking motion. The angle value [°] can be typed into the correspondent field or set via the slider displayed below.
Slice animation These tools are only applicable to MPRs.		
	**Play/Stop**	starts/stops the animation.
	**Speed**	changes the animation speed.
	**Range limiter**	determines the border of the animation by shifting the borders.
Scalpel These tools are only applicable to VR.		
	**Scalpel contour inside**	removes an unwanted sector defined by a freehand spline within the VR. Keep the left mouse button pressed while the spline is drawn by mouse move. Releasing the pressed button the circumscribed contour will automatically be closed.
	**Scalpel contour outside**	removes everything outside a sector defined by a freehand spline. Keep the left mouse button pressed while the spline is drawn by mouse move. Releasing the pressed button the circumscribed contour will automatically be closed.
	**Scalpel box inside**	removes an unwanted sector defined by a rectangular spline. Keep the left mouse button pressed while the rectangle is drawn by mouse move. Releasing the pressed button ends the drawing of the rectangle.
	**Scalpel box outside**	removes everything outside a sector defined by a rectangular spline. Keep the left mouse button pressed while the rectangle is drawn by mouse move. Releasing the pressed button ends the drawing of the rectangle.

	**Small circle eraser**	removes everything beneath the mouse pointer (small eraser). Keep the left mouse button pressed to remove immediately everything beneath the mouse pointer.
	**Medium circle eraser**	removes everything beneath the mouse pointer (medium eraser). Keep the left mouse button pressed to remove immediately everything beneath the mouse pointer.
	**Big circle eraser**	removes everything beneath the mouse pointer (big eraser). Keep the left mouse button pressed to remove immediately everything beneath the mouse pointer.
	**Scalpel undo**	undoes the last change performed by a scalpel tool.
	**Scalpel redo**	redoes the last change previously undone before.
	**Scalpel remove**	recovers the last deleted sector done with the Scalpel tool.

10.4.5 Toolspace - Measurements tab

It contains tools for 2D and 3D measurements, which can manually be performed.

All measurement tools provided there can only be applied to MPRs. After having finished a measurement it is displayed at the VR too.

Each measurement is displayed as a green contour and is labeled with its own number. The numbers are consecutively generated by the system.

Each value belonging to the particular measurement is displayed at the upper left corner of this tile within the measurement was performed before.

The measurement functionalities are only available on calibrated datasets. They can only be performed on static images. Stop any animation before performing measurements.

At animated phase sequences measurements are only visible in that phase of the sequence they were performed before.

Button	Name	Function
	**Measurements tab**	These tools allow 2D and 3D measurements, which can manually be performed.

Measurements		
	**Distance**	measures a distance between two defined points within a tile. Reposition one of the points by drag and drop.
	**Angle**	calculates an angle between three defined points within a tile. Reposition one of the points by drag and drop.
	**Area**	calculates an area defined by a spline within a tile. The spline will be closed with a double click at the last spline point or a right mouse click. Reposition one of the points by drag and drop. Add a point to the spline with a click on the line between two points. Delete one point of the spline with a right click on it.
	**Curve**	calculates a curve defined by a spline. Fix the end of the curve with a double click or a right mouse click. Reposition one of the points by drag and drop. Add a point to the spline with a click on the line between two points. Delete one point of the spline with a right click on it.
	**Delete measurement**	removes only the measurement performed at last or changed at last.
	**Delete all measurements**	removes all existing measurements displayed in the Workspace.
Measurement regain This function is only applicable to 2D measurements. 2D measurements performed in a certain slice are badly to recover as soon as the user navigates within MPRs. The Measurement regain functionality automatically navigates to the slice within the 2D measurement was done.		
	**Overview window**	All existing 2D measurements are listed within the overview window.
	**Regain selected measurement**	Select a measurement within the overview window to recover a slice with a specific measurement and click onto the Regain selected measurement button.

Volume Measurement

Sectional workflow: Volume Measurement

Activate Volume Measurement mode. Click on the Volume Measurement button.

Contour tracing upper left tile. Mark the beginning of the contour, which has to be traced, in the upper left image with the first mouse-click. Follow the contour of the structure by placing consecutive points. Close the area by placing the last spline point onto the first one or using a double click at the last spline point. The circumference of the traced area will be displayed as a colored line.

Reposition one of the points by drag and drop.

Add a point to the spline with a click on the line between two points.

Delete one point of the spline with a right click on it.

Contour tracing upper right tile. Redo the procedure described the step before within this tile. The cut plane in the upper right tile is orthogonal to the one in upper left tile. Place this contour between the two white crosses displayed on the vertical line of intersection. It represents the cut plane displayed at the upper left tile.

Double number of planes (optional). The amount of cut planes taken into account for the measurement can be doubled if a more precise reproduction of the volume is required. Each plane requires a new contour tracing and contour checking.

Calculate Volume. Calculates the traced volume. Only one volume object per frame can be calculated. The calculated result is displayed at the upper right corner of the VR tile.

Displaying volumes. The calculated surface of the volume is displayed in the VR tile with a green color (only visible in the Layouts Volume and Cubic View).

	**Volume Measurement**	activates the Volume Measurement mode.

Plane Controls

These tools are offered to the examiner to improve the accuracy of a performed volume measurement.

	**Previous plane pair**	displays the previous plane pair in the upper tiles.
	**Next plane pair**	displays the next plane pair in the upper tiles.
	**Add plane pair**	doubles the amount of cut planes taken into account for the measurement.
	**Remove plane pair**	reduces the amount of cut planes taken into account for the measurement to half the amount.
	**Calculate**	calculates a traced volume.
	**Delete contour in active plane**	removes the contour displayed within the active tile. Each contour, which should be removed, has to be displayed in the active tile first. Hidden contours - when the wrong frame is displayed – cannot be removed.

	**Delete all contours**	removes all traced areas and the calculated body volume.
Volume transparency This function is only applicable to VR.		
	Modify transparency of volume	determines the appearance of a calculated beutel. A value of 0 creates a solid surface. Increasing this value the transparency of the beutel is increased too.
Annotations These functions are only applicable to MPRs.		
	**Annotation**	adds an annotation at any point within the MPR. After a left mouse click within the MPR a textual window appears. Any text can be written within the window. Terminate the entries with a left mouse click or the ENTER button. Perform a right mouse click onto an existing text field to edit it. Relocate an existing text field by drag'n'drop.
	**Arrow**	adds an arrow at any location within the MPR. The arrow is defined by two left mouse clicks. The first one defines the arrow basis and the other one its head.
	**Delete annotation**	undoes the last action (Annotation or Arrow).
	**Delete all annotations**	undoes all actions.

10.4.6 Toolspace – Layout Settings tab

It contains different layout concepts.

Button, slider, icon	Name	Function
	**Layout Settings tab**	These tools allow displaying different layout concepts.
Volume		
	**Synchronize VR/MPR**	couples the display of the MPRs with the VR. The navigation done within one tile is done to the other tiles too, because the navigation is synchronized.
	**Centerpoint-navigation**	fades in a crosshairs within the MPRs. With crosshairs it is possible to navigate through the volume. Further it is possible to shift the center of the crosshairs as well as the axes. To rotate the axes grab them at their

		ends.
Cubic View Cubic View is a layout to display the three MPR views - which can normally be found in the A-, B- or C-Plane - in one view, the cubic view. These three MPRs are perpendicular to each other.		
	**Box**	changes the outward size of the Box, which limits the visible parts of the MPRs. Keep the left mouse button pressed inside a plane of the cube and move the mouse left/right to relocate this plane.
	**Niche**	changes the size of the Niche, which uncovers visible parts of the MPRs. Keep the left mouse button pressed inside a plane of the niche and move the mouse left/right to relocate this plane.
	**Plane**	relocates the spatial position of the MPRs displayed within the cube. Keep the left mouse button pressed inside a MPR and move the mouse left/right to relocate it.
Curved-Slice A Curved-Slice cut out of the VR is defined by a green spline in a MPR and displayed within the VR tile. The value belonging to the Curved-Slice is displayed at the upper right corner of this tile.		
	**Curved planar reconstruction**	calculates a Curved-Slice defined by a spline. Fix the end of the curve with a double click or a right mouse click. Reposition one of the points by drag and drop. Add a point to the spline with a click on the line between two points. Delete one point of the spline with a right click on it.
	**Three curved planar reconstructions**	calculates three times the same curved slice in different tiles. Later the render settings can individually be changed within the different tiles.
	**Direct**	The length of the Curved-Slice is the same as the length of the spline.
	**Projected**	The length of the Curved-Slice is defined by the length of a direct line between the start point and the end point of the spline.
	Thickness	changes the Thickness of a Thick Curved Slice by: using the arrow up/down buttons typing the desired value in the Thickness field.

	**Delete spline**	removes the spline and its associated MPR. Please select with a mouse click the MPR before, which should be removed.
	**Delete all splines**	removes all splines and their associated MPRs.

Multi-Slice

Each tile displaying an equidistant slice has a value at its lower left corner. This value shows the distance of the particular slice to the center of the VR.

	**A-plane**	displays the equidistant slices in direction of the A-Plane.
	**B-plane**	displays the equidistant slices in direction of the B-Plane.
	**C-plane**	displays the equidistant slices in direction of the C-Plane.
	**Reference display**	replaces the first slice in the upper left tile with a plane, which is orthogonal to the direction of the selected equidistant slices. Inside this plane there are parallel dashed lines representing the equidistant slices. One dashed line has a green color. It indicates the position of the slice displayed in the current active tile among the other slices.
	**Dual tile**	displays a horizontal dual tiling of the Workspace.
	**Quad tile**	displays a quad tiling of the Workspace.
	**Nine tile**	displays a nine tiling of the Workspace divided in 3rows and 3columns.
	**16 tile**	displays a sixteen tiling of the Workspace divided in 4rows and 4columns.
	**Previous plane**	shifts the package of equidistant slices about one plane in negative direction.
	**Next plane**	shifts the package of equidistant slices about one plane in positive direction.
	Slice pitch	changes the distance between two neighboring slices within the package of equidistant slices.

Multi-Slice D'art

Each tile displaying an equidistant cut plane has a value at its lower left corner. This value shows the distance from the particular cut plane to the center of the VR.

	**Quad tile**	displays a quad tiling of the Workspace.

	**Nine tile**	displays a nine tiling of the Workspace divided in 3rows and 3columns.
	**16 tile**	displays a sixteen tiling of the Workspace divided in 4rows and 4columns.
	Slice pitch	changes the distance between two neighboring slices within the package of equidistant slices.

Compare mode

At the Compare mode two datasets of the same patient can be compared in a side by side comparison. The planes (A-, B-, C-), which should be compared, can be selected by correspondent buttons.

Volume		
	**Region of interest on/off**	Each MPR tile displays an area limited by green angles. This area is named as Region of Interest (ROI). It is a function for reducing the size of a dataset. Only the MPR at the A-plane has an additional green dotted line between the upper angles (Flexible Cutline). Keep the left mouse button pressed on a green angle and move the mouse to resize the ROI horizontally and/or vertically. Keep the left mouse button pressed on the green point within the Flexible Cutline. Move the mouse to redefine the position of this point within it and to reshape it too. All tissue outside this box will be ignored for displaying the VR.
	**Synchronize left/right**	couples the displays of the datasets shown on the left and right side of the workspace. The navigation done within one tile is done to the other tiles too, because the navigation is synchronized.
View configuration		
	**Compare A-plane**	displays the particular A-plane MPRs of both datasets used for a side by side comparison.
	**Compare B-plane**	displays the particular B-plane MPRs of both datasets used for a side by side comparison.
	**Compare C-plane**	displays the particular C-plane MPRs of both datasets used for a side by side comparison.
	**Compare 3D**	displays the particular VRs of both datasets used for a side by side comparison.

10.4.7 Toolspace – Color Settings tab

Button, slider, field	Name	Function
	**Color settings tab**	These tools allow changing different layout concepts of Doppler datasets.
Doppler display mode These functions are only applicable to the VR.		
	**Plane cut tissue**	displays Doppler contents and a cut plane.
	**Cube cut tissue**	displays Doppler contents and the tissue.
	**Fusion 3D**	displays Doppler contents shining through the tissue.
	**Cube cut all**	displays Doppler contents and the tissue cut at a defined point.
	**Doppler**	displays Doppler contents.
	**MIP doppler**	displays Doppler contents in a projection of maximum intensity.
Doppler component		
	**Show tissue**	displays only tissue.
	**Show doppler and tissue**	displays Doppler contents and tissue.
Doppler Threshold/Transparency These functions are only applicable to the VR.		
	**Threshold Doppler**	separates an object of interest from the background and/or unwanted data (noise). Threshold settings help to define which structures are relevant for the reconstruction and which ones are not. Color values above the adjusted threshold are taken into account for the reconstruction, and color values below are ignored.
	**Transparency Doppler**	determines the appearance of a rendered volume. A value of 10 creates a solid surface. Increasing this value the transparency of the volume is increased too.

Doppler texture intensity		
These functions are only applicable to the VR.		
	**Texture intensity doppler**	changes the intensity of the surface of the Doppler volume.
Power		
These functions are only applicable to the Doppler parts.		
	Palette	applies one of the available color schemes to the Doppler parts of the volume.
	Balance	changes the part of pixels within the MPRs which can be displayed in terms of color. Annoying color parts can be removed by adaptation of the balance value.
	Power DR	changes the dynamic range of the Doppler color.
CDI		
These functions are only applicable to the Doppler parts. Velocity and velocity turbulence are available as sub modes of CDI.		
	Palette	applies one of the available color schemes to the Doppler parts of the volume.
	Balance	changes the part of pixels within the MPRs which can be displayed in terms of color. Annoying color parts can be removed by adaptation of the balance value.
	Baseline	shifts the baseline of the color scale bar. It can be used for a better display of anatomical structures.
	**Baseline reverse**	mirrors the color scale bar around its baseline.
Dynamic flow		
These functions are only applicable to the Doppler parts.		
	Palette	applies one of the available color schemes to the Doppler parts of the volume.
	**Baseline reverse**	mirrors the color scale bar around its baseline.

10.5 Annex: Measurements

Take any information needed about the measurements calculated by the system or manually performed by the user from the table below:

Measurement	[Unit]	Description	maximum allowed absolute deviation
2D Manual Measurements			
Distance	cm	Measures a distance between two defined points within a MPR. Points can be repositioned by drag and drop.	10%
Angle	°	Calculates an angle between two lines (3 points) defined within a MPR. Points can be repositioned by drag and drop.	10%
Area and Circumference	cm^2 and cm	Calculates an area and circumference defined by a spline within a MPR (or VR).Points can be repositioned by drag and drop. Add a point to the spline with a left-click on the line between two points.	10%
Curve	cm	Calculates a distance which is defined by intersection points. The intersection points can be set individually. At least three intersection points have to be set before the measurement can be completed. Points can be repositioned by drag and drop.	10%
3D Volume Measurement (calculated by system)			
Volume	ml	Calculates the volume of an object. The volume will be defined by adding splines to different MPRs in the three dimensional space.	10%

11 Abbreviations and Functions

Medical as well as product specific abbreviations and functionalities used in this manual:

3D	3D rendering view
A4Ch	Apical four chamber view of the heart
A3Ch	Apical three chamber view of the heart
A2Ch	Apical two chamber view of the heart
AV	Aortic valve
Beutel™	Evaluated and optimized static/dynamic model of the left ventricle
ECG	Electrocardiogram
ED	End-diastole
ES	End-systole
LAX	Long axis view
LM	Landmark
LOI	The Line of intersection represents the cross section of another imaging plane with the currently displayed one.
LV	Left ventricle
LVOT	Left ventricle outflow track
MPR	Multiplanar reconstruction of an image
MV	Mitral valve
Orbit	Functionality for the rotation of a reconstruction around its vertical/horizontal axis
Polar plot	2-dimensional illustration of the surface of the left ventricle. This surface can be covered by different maps (e.g. parametric maps).
ROI	Region of interest
RV	Right ventricle
SAX	Short axis view
SE	Standard Edition
Slice	Functionality for moving in parallel slices through a dataset
TEE	Transesophageal echocardiography
TTE	Transthoracic echocardiography
TV	Tricuspid valve

12 Table of Keyboard Shortcuts

- Image-Com
- 4D LV-Analysis/Function
- 4D Cardio-View
- 4D MV-Assessment
- Echo-Com

Shortcut	Function
Tile navigation	
<Left mouse click>	activate tile
<Tab>	activate next tile
<Shift + Tab>	activate previous tile
<Ctrl + Left mouse click>	select/deselect tiles
<Return> / <Enter>	toggle tile display
Sequence navigation	
<Space>	start/stop the sequence(s)
<Mouse wheel>	step forth and back through a sequence
<Cursor Left>	decrement the actual frame
<Cursor Right>	increment the actual frame
<CTRL + Cursor Left>	go to the Start position slider
<CTRL + Cursor Right>	go to the End position slider
Paging	
<Page Up> or <Cursor Up>	go page up
<Page Down> or <Cursor Down>	go page down
<Home> or <CTRL + Cursor up>	go to first page
<End> or <CTRL + Cursor down>	go to last page
Slice	
<Shift + mouse wheel>	slice MPR

Zoom	
<CTRL + '+'>	zoom in
<CTRL + '-'>	zoom out
<Ctrl + mouse wheel>	zoom in/out
Measurements	
<n>	go to the next measurement in a package

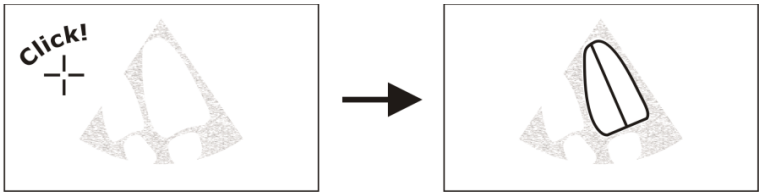
13 Quick Instructions - Automatic Detection Modules

- AutoLV
- AutoIMT

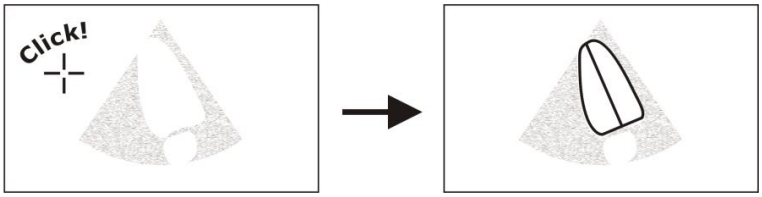
13.1 AutoLV

1.) , Exam Type "Echo"

2.) Left Ventricle ->Simpson ->4CH ->



3.) Left Ventricle ->Simpson ->2CH ->



13.2 AutoIMT

1.) , Exam Type "Carotid"

2.) IMT ->